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RADIO and ELECTRONICS

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OUR COVER

This month we feature a view of the Narrow-band F.M. Exciter described on Page 9 of this issue.

AN APOLOGY

Through circumstances outside our control we regret that it is not possible in this issue to complete the description of the "Senior Communications Receiver." This has had to be held over until next issue, when photographs of the completed set will be featured in the final instalment.

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A QUESTION OF STANDARDS

The Government, it is hoped, will soon make an announcement of its intentions with respect to the establishment of a television service in this country. This decision, whatever form it may take, and whatever it may be, should not be held up or affected in any way by the ultimate necessity for settling upon a set of transmission standards suitable for our needs. The fixing of standards will, however, be one of the most urgent matters for consideration, should the Government decide that we are to have TV, and there are good reasons for urging that standards should be decided as soon as possible, even if the main decision indicates that we will have to wait some time yet for the establishment of a service. Chief among these is that those who will be affected in a pratcical way when television does come should know as far in advance as possible to what standards they will be expected to work.

The question is one that is fraught with controversy, for there are no international standards which, if they existed, would settle the matter without leaving scope for argument. And as if to make things more difficult, many of the salient parts of the rival standards at present operating or projected for use in the near future, appear to be capable of more or less arbitrary fixing, without great consequence either to the probable quality of the pictures or to the pockets of the public.

To illustrate what we mean, let us briefly examine the existing British and American standards. There is a major difference, of course, in the numbers of lines used—405 as again 525—and this question of the number of lines is one of the most important ones to be settled, but some of the other differences appear smaller and of less consequence. For example, in Britain, the polarity with which the video signal is modulated on the carrier is the opposite of that used in America. The matter seems to be one of some importance technically, and there are distinct advantages and disadvantages on both sides. Positive modulation, as used in Britain uses the carrier as follows: The synchronizing signals always occupy the portion between zero and 30 per cent. maximum amplitude, the latter representing black. Maximum amplitude then represents full white. In the American system, however, maximum amplitude is the tips of the synch. pulses, which extend downwards to 75 per cent. which represents black. A minimum level of 5 per cent. then represents white.

With positive modulation, any interference signals will cause a splash of white on the screen, while with negative modulation, interference will give black spots, and it is considered that this reduces considerably the annoyance value of interference. On the other hand, when maximum carrier amplitude is used for the synch. pulses, interference has a much more marked effect on the synchronization than when the opposite is the case, and in this respect the Brtiish system has the advantage. This and many other points have to be decided when standards are laid down, but undoubtedly the most important decision is that concerning the number of lines per picture.

In considering this problem, a great many things have to be taken into acocunt, and by no means all of them are directly connected with the purely technical aspect of the situation. The most obvious effect is the apparent improvement in picture quality which results when the number of scanning lines is increased. We say "apparent," because it is not generally realized that the mere increasing of the number of lines does not necessarily result in a better-quality picture at all. It can be shown theoretically, that if this is done, the picture is actually made worse, unless the change is accompanied by another equally important extension. We refer, of course, to an increase in the video bandwidth used by the whole system, transmitting and receiving alike. This fact is amply borne out in practice, too, by many observers who consider that in spite of the greater number of lines used, the average result on home receivers in America is actually inferior to that obtained in Britain. And it is here that pure technicalities start to be overshadowed, because if this is so, it must be due to only one thing—namely, the expense involved in increasing the bandwidth of a TV receiver. Any increase in bandwidth of equipment used in TV must result at present in increased cost of that equipment, so that the situation in America would appear to be this: that in spite of the potentially higher-quality picture allowable by the American standards compared with the British, the perpetual race to reduce the price of TV receivers has had such an effect on receiver design as to prevent any actual improvement from being realized at all by the people who count—the public.

This one example of what can happen to potential improvements due to raising the standards should act as a warning example to all those who will in any way be concerned with deciding on what our own standards are to be. The decisions have already been made in Australia, where it has been decided to have 625 lines, and it is by no means certain that the choice was a wise one. It does not appear that the ultimate standards will be as low as this, since long-term plans everywhere seem to indicate that the figure will eventually be higher still, so that everyone now engaged in TV will have to face a change in standards sooner or later. This being the case, there is surely considerable latitude in deciding what should be used in any system shortly to be instituted. It may be to our advantage to settle for the same standards as Australia, since we are so close, but there seems a real danger attached to the 625-line decision. It is that the Australian viewer will get either a very expensive set, of considerably higher than the minimum acceptable quality, or else, an inferior set which will still be costly, but which could give better results than it does were the standards not qutie so high. In practice, both types will probably find their way on to the market, but there is little doubt that a more modest standard would give acceptable pictures at lower cost to the consumer.

To Our Readers

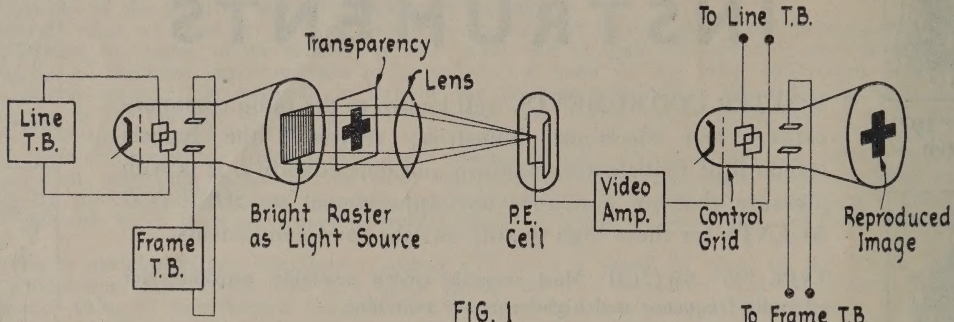
The Editor and staff of "Radio and Electronics" extend their best wishes for the new year which has already commenced, to all our readers, with the hope that 1951 will be a year of health, pleasure, and prosperity to every one of them, and that this journal will continue to provide for them the interest and pleasure which it is our constant effort to excite.

THE "R. & E." AMATEUR TELEVISION PROJECT

PART II

THE LINE AND FRAME TIME-BASE UNIT

In Part I of this series of articles the principle of the flying-spot scanning system was described in general terms, and the equipment units that would be needed in order to put the system into operation were outlined. This month's instalment describes some of the difficulties that we can expect to meet, how it is proposed to overcome them, and then describes the circuit of the line and frame time-bases that have already been developed for this purpose in our laboratory.



Diagrammatic representation of the scheme to be used, showing how one cathode ray tube, together with a transparency and a P.E. cell, produces a video signal which is reproduced on the "receiving" C.R.T.

SOME DIFFICULTIES THAT CAN BE EXPECTED

As readers will probably have realized before now, the principle of the arrangement for transmitting still transparencies is really quite simple. There are, however, certain things that will not be too easily overcome in practice, owing mostly to the fact that it is intended to use, as far as possible, standard parts. For instance, the performance of the whole system will depend to a large extent on the quality of the cathode ray tubes used. If the supply of gear were no difficulty, the proper way to tackle the job would be to use magnetically deflected tubes with white screens. In short, standard receiving tubes as used in TV sets. Unfortunately, these are as yet unavailable, and even if they were, they would probably be rather expensive for the amateur experimenter to purchase two of them easily. The alternative, of course, is to use ordinary oscilloscope tubes, with green screens and electrostatic deflection. These are certainly available at prices within the amateur experimenter's pocket, which is perhaps the first essential. Unfortunately, however, the characteristics of the screen material are not all that could be desired for the purpose in hand. We do not refer to the green colour of the trace, which can be tolerated, especially if the resolution is good enough to give a high-definition picture. The trouble is due to the persistence characteristic. The various materials used to coat the screens of cathode ray tubes differ most markedly in their colour, and in their persistence. By the latter is meant the rate at which the light from the screen decays after the electron beam has passed on to another part of the screen. Ideally, of course, there should be no persistence at all, the light decreasing immediately to zero as soon as the stimulus, in the shape of the electron beam, has been removed. The white-screen materials used for proper TV tubes has a short persistence, and the light blue screens of tubes specially designed for observing high-speed waveforms that are not recurrent, have a shorter persistence still. In fact, of all the usual types of screen material, the one used in the common green tube has the longest persistence. What, then, is the effect if we use a long-persistence screen, and how, if at all, does this degrade the image?

Just how can easily be seen by anyone who has an oscilloscope. If the tube is adjusted to give a spot, undeflected by any time-base or other voltage applied to the deflecting plates, it is possible to move the spot reasonably fast by taking the shift control and rotating it quickly. When this is done, the persistence of the screen, together with the persistence of vision, makes the spot look rather like a comet with a "tail" rather than just a moving spot. As a result, if such a tube is used to produce *moving* images, there will be what is usually called a "trailing ghost" when the image moves. However, for still transparencies, the effect just mentioned will be absent, because the image does not move. It will thus be a matter for experiment to see whether the green-screen tubes will give satisfactory results. At this juncture, we would like to ask readers not to take to heart too much the so-called difficulties that we are describing. When we say "difficulties" we do not mean that they will prevent us from getting a picture at all. For experimental work of this kind we will be more than satisfied if we get a result even half as good as a standard TV picture, because we realize that the equipment we are working with is not really designed for the purpose for which we will use it. Even so, there are certain saving graces that lead us to believe that our efforts will be far from wasted. For example, those who read English radio periodicals will no doubt have been struck by the fact that certain firms regularly advertise TV kits for constructors' use that feature the well-known VCR97 as the receiving tube. If the results on the standard transmissions of the B.B.C. are not reasonably satisfactory even with these tubes, which are 6 in. ones with the ordinary green screen material, it is hardly likely that the kits would continue to find a sale.

Another difficulty of which the proof will, as it were, be in the eating, is that of obtaining a sufficiently high signal-to-noise ratio to get a satisfactory picture. Now this aspect of the problem depends on two things. First, the strength of the light source, and secondly, on the sensitivity of the P.E. cell used to pick up the video signal. As can readily be appreciated, the light source with which we have to deal is the spot of the transmiting cathode ray tube, and this is a very weak source indeed in the ordinary way. Nor is there very much we can do about making it stronger. The other factor is a most important one, and it appears that it may possibly be the limiting factor with which we will have to contend. However, time and laboratory work will tell, and we hope to have the full story at a later date. The trouble is that the photocells that it is possible to use are very insensitive. These are of the vacuum type; gas-filled cells, such as are used in talkie projectors are impracticable, because their frequency response is not nearly wide enough. Their response starts to fall off inside the audio frequency range, so that there is no chance at all of using them here, where they are asked to respond to frequencies of several megacycles per second. The vacuum phototube, on the other hand, has a frequency response that is limited almost solely by transit time, so that no difficulty need be expected on that score. The only trouble is, that their sensitivity is several times smaller that that of the gas phototubes which cannot be used. The current sensitivity of almost all vacuum cells is of the order of 20 microamps per lumen, which is itself not a very great quantity of light. The amount of light output from the C.R.T. spot is only a very very minute fraction of a lumen, so that when this varies in accordance with the light and shade of the scene being scanned, the variation in the output current of the cell can be expected to be only a very small fraction of a microampere.

In order to convert this current change into an output voltage, we do the obvious thing and connect the cell in series with a load resistor, so that the change of cell current through this resistor produces a voltage across it. This voltage is then applied to the grid of the first video amplifier tube, and if we have a very high-gain amplifier, it should be possible to obtain enough output voltage from the last amplifier stage to modulate the grid of the receiving cathode ray tube. There is only one snag to this, however, and it is that the original voltage to be amplified is so small as to be likely to be masked by the amplifier noise. In other words, the required amplifier gain is likely to be so high that valve noise, and thermal agitation noise arising in the load resistor of the photocell, may be of the same order of amplitude as the voltage we are trying to amplify. One obvious way out of this dilemma is to increase the size of the original voltage from the P.E. cell by increasing the intensity of the light source until the output voltage is much greater than these two kinds of noise. Another way is to produce out of the hat a photocell which has a much greater sensitivity, but little or no increase in noise output. Such a photocell is the electron-multiplier type of photocell. This tube has an ordinary vacuum type of photocell inside it, but in addition, it has a nine-stage secondary emission amplifier built into the same envelope. This type of amplifier has a much

better signal-to-noise ratio than a conventional valve amplifier of equivalent gain, because it uses no resistors which can generate noise, the amplification arising purely through the action of the stream of electrons, which gets larger and larger as it passes through each secondary-emission stage. It is this kind of tube, therefore, that is used in commercial film scanners, used in TV broadcast stations for transmitting film instead of direct camera scenes. Unfortunately, these *multiplier phototubes,* as they are called, are extremely expensive in the ordinary way—about £12 to £15 each—so that they, too, would appear to be completely ruled out on the score of expense. Luckily, however, it appears that great numbers of them were used for special purposes during the war, with the result that both in Britain and America they are available from war surplus stocks at about 30s. each. The tubes we are referring to are the R.C.A. 931A. With the followers of this Project in mind, we are arranging for some importers to bring in some of these tubes so that they will be available for those who wish to build the gear we will be describing. However, before they arrive, we intend to see just to what extent it may be possible to use an ordinary vacuum photocell, together with a high-gain video amplifier.

In doing this, it is also intended to tackle the problem from the other end at the same time. It is always possible to increase the brilliance of the spot of a cathode ray tube by putting an increased E.H.T. voltage on the final anode. The VCR97s that we will use for our own experiments (since these are considerably better than 5BP1s) are rated to take a maximum voltage of 2000 volts. Now, the almost identical C.R.T.s that have been produced since the war under individual firm's type numbers are rated to take 5000 volts on the final anode, and 2500 on the first anode. It may be, therefore, that the VCR97s will quite well take the same voltages. It is highly probable that for Service purposes, they were rated rather lower than necessary, in view of the fact that they were carried in high-flying aircraft, where the reduced atmospheric pressure would impose lower voltage limits on the insulation in the bases of the tubes. Thus, it does not seem likely that in ordinary use, the VCR97 will not stand an anode voltage of 5000. It is also a common practice to over-volt some oscilloscope tubes in order to brighten the spot for observing high-speed traces. Thus, we should be able to get a much brighter light source by increasing the E.H.T. voltage, and it does not seem likely that the cathode ray tubes will come to any harm. It will not be necessary to increase the voltage on the receiving tube, which can be run under ordinary conditions.

From the above, it will be seen that there are plenty of things to think about if the project is to be fully successful. However, several aspects of the project present very little difficulty, and on the constructional side, the first piece of equipment to be tackled successfully has been the time-base unit.

THE TIME-BASE UNIT

The first piece of circuitry that has been developed to date is the time-base and deflection amplifier unit, whose circuit is printed here. The scheme of the unit can perhaps be better appreciated from the block diagram, Fig. 2. The job of the time-base and amplifier unit is to produce the raster on the face of the transmitting tube, and in the first instance it will also be used to deflect the receiving tube at the same time, as indicated on the schematic diagram, Fig. 1.

The unit subdivides itself readily into two main portions. These are the horizontal time-base and amplifier circuit, and the vertical time-base and amplifier circuit respectively. In addition, there are two extra valves whose job it is to provide a black-out voltage, which is applied to the C.R.T. control grid, in the case of the transmitting tube only. Both horizontal and vertical deflecting voltages are of the usual saw-tooth waveform, and while steps have been taken to make the flyback in each case as rapid as possible, it is not difficult to arrange that the flyback in each deflection will be invisible. This is a refinement in the present case, but one that will be found well worth-while. In standard television transmission it is not regarded as anything but a necessity, and is always done. In TV receivers it is not necessary to do anything about it, because the transmitted

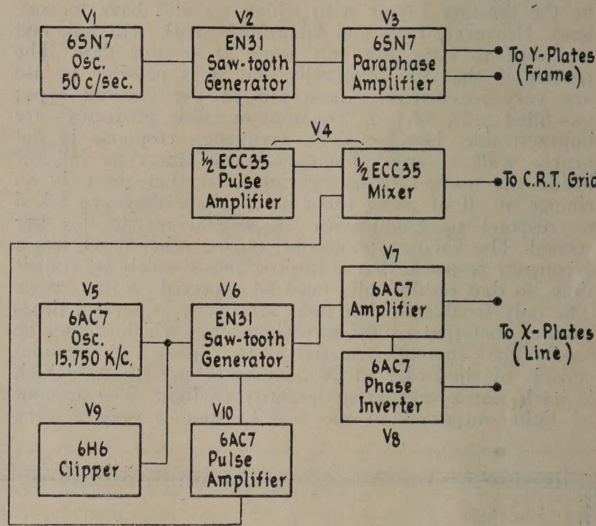


Fig. 2—Block diagram of the deflecting and blanking circuits shown in detail on page 7.

video signal performs the black-out function automatically when the receiver's time-bases are locked to the transmitted synch. pulses, as they must be for proper operation of the set.

On the block diagram, V_1, V_2, and V_3 provide the frame time-base, which is, of course, applied to the Y plates of the C.R.T. to give a vertical deflection. This is the simplest part of the circuit, because it is a very easy matter to generate and amplify a saw-tooth at the frame frequency, which has been chosen as 50 c/sec. This is high enough to eliminate flicker of the image, and has the further advantage that if later we wish to lock the transmission to the mains, only simple modifications will be needed. V_1, a 6SN7, is a straightforward triode multivibrator, working at 50 c/sec., and gives a square-wave output which is used to trigger the time-base tube, V_2. The latter is an EN31, which is a gas triode specially designed for use in oscilloscope time-base circuits. It is a similar sort of valve to the American gas triodes 884 and 885, which are designed for the same purpose, but which are no longer available. The EN31 has a 6.3 volt heater, and has the advantage that it works much better at high saw-tooth frequencies than the other tubes. V_3, another 6SN7, is a simple paraphase amplifier, giving a push-pull output so that we can have balanced deflection on the Y plates. This is a slight extra complication compared with the ordinary single-ended deflection most commonly used with oscilloscopes, but in the case of television is well worth it, because balanced deflection improves the overall focus of the spot, and gives an equally well-focused spot all over the screen. Single-ended deflection on the other hand does not do this, and the use of

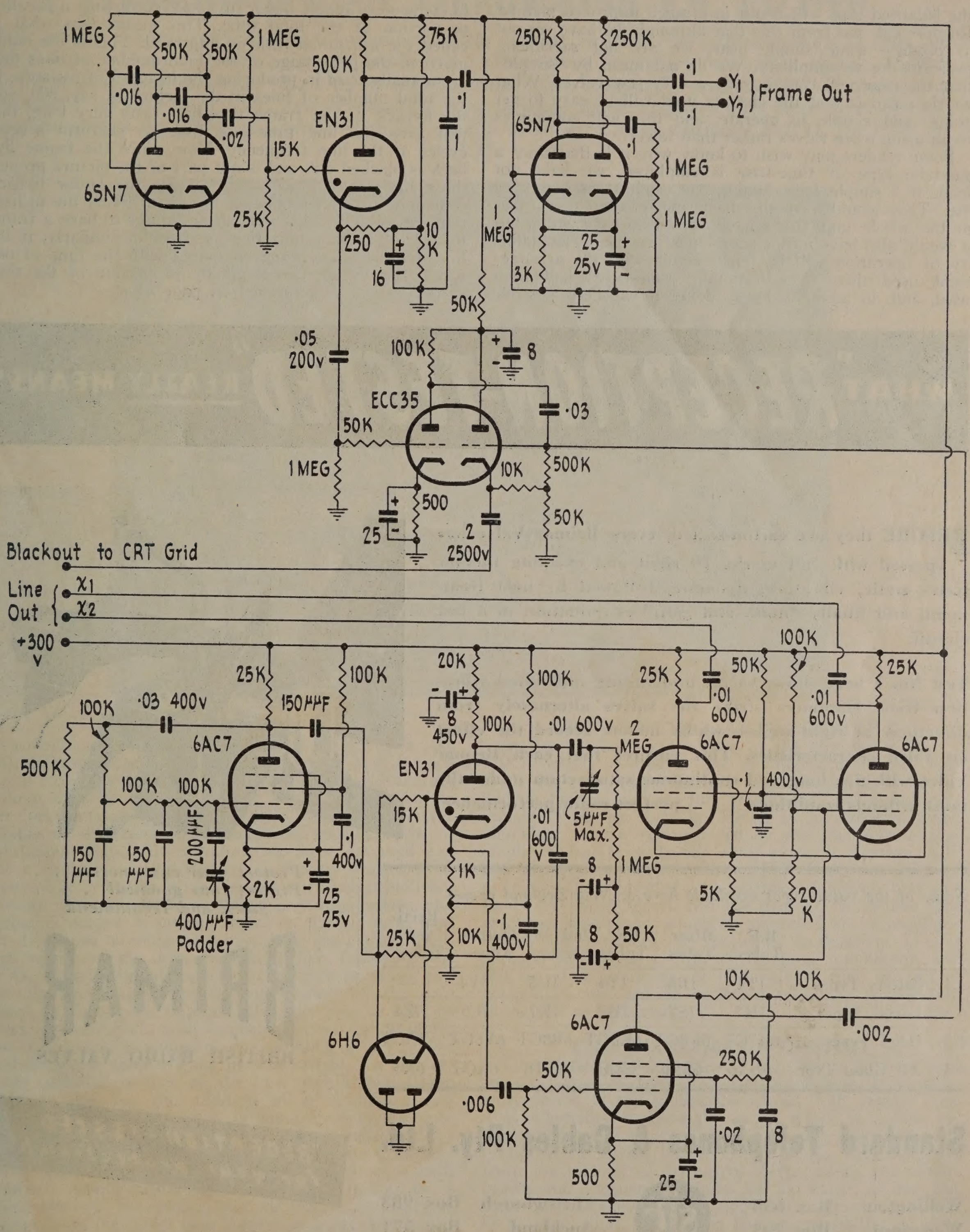


Fig. 3.—Complete circuit for the frame and line deflecting units, together with arrangements for blacking out, or blanking, the flyback of both time-bases.

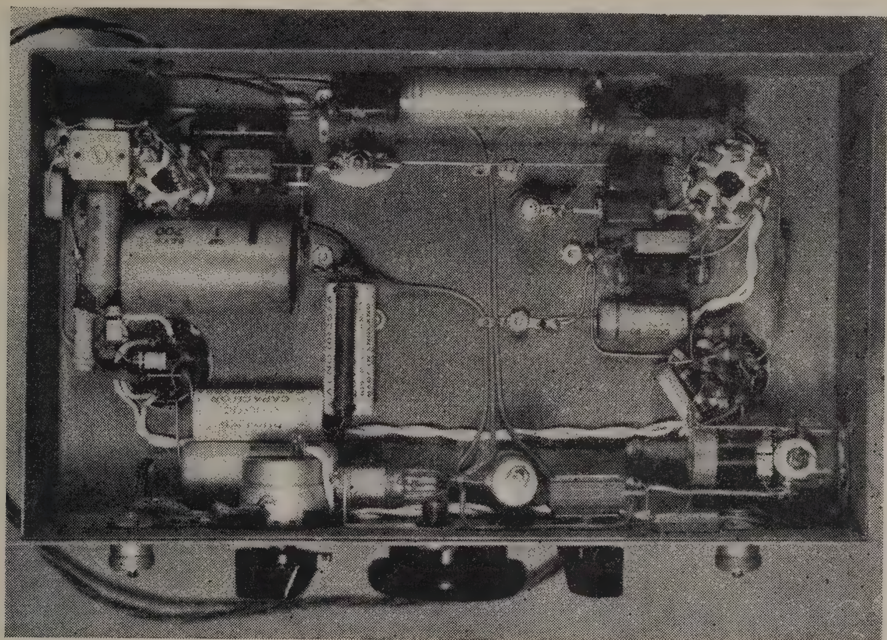
the balanced type will result in a much improved picture. Readers can see from this that although we have set out to produce some simple gear, we are not sacrificing performance to simplicity. We do not mean by "simple" that the gear will contain only a very few valves. What we do mean is that the circuits used will be easy to get going, and simple to operate, and this will sometimes mean using more valves rather than fewer.

Some readers may wish to know why it is that since a gas-tube type of time-base is employed, we have not made it a simple free-running one, such as oscilloscopes use. This would certainly have meant that two tubes in the whole unit could have been dispensed with, but it would also have meant poorer performance. The stability of operation will be much better with the arrangement used than if self-running time-bases had been used, and, in addition, by so doing it has been possible to achieve a much better flyback, occupying a smaller proportion of the total time. This means that what is called the *utilization ratio* is improved. This is the name given to the percentage of the total number of lines that are actually *used* in producing the image. For instance, if the total number of lines in the picture is, say, 300, and the flyback of the frame time-base lasts very long, this will give the line time-base time to perform several cycles at the line frequency. Now, since the frame flyback is blacked out, and is not part of the picture proper, those line scans which occur during the frame flyback cannot be used in producing the picture, and the utilization ratio is low. It is thus an advantage to have a frame flyback of as short duration as possible. Similarly, if the line flyback is not short compared with the time of one whole line cycle, then a goodly proportion of the time

(Continued on page 41.)

A STRAIGHTFORWARD NARROW-BAND F.M. EXCITER

One of the reasons why so few amateurs seem to indulge in N.B.F.M. transmission is that not very many suitable circuits exist for producing a satisfactory frequency-modulated signal. Another is the difficulty of receiving this kind of transmission with standard receivers. This month we present a narrow-band F.M. exciter which is easy to make work, requires only four tubes, including the speech amplifier, and which is stable enough to be used as an ordinary V.F.O. for C.W. or A.M.



INTRODUCTION

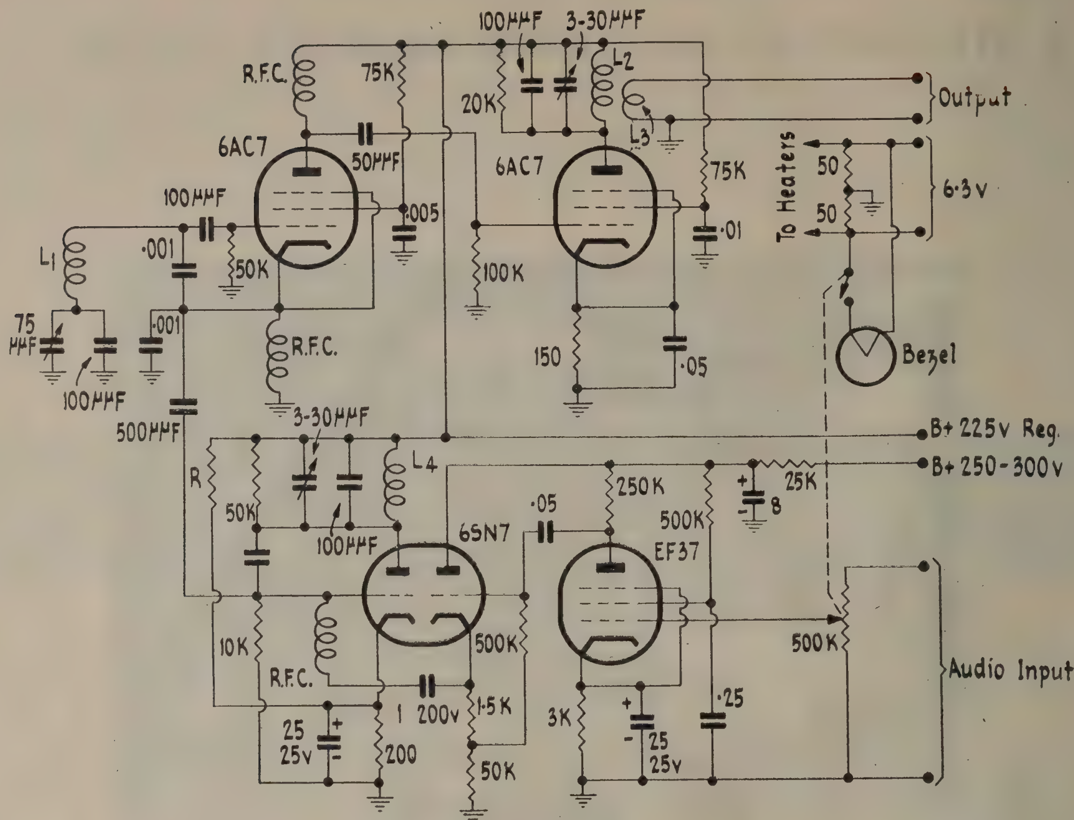
Although overseas journals which cater for the amateur transmitter have of recent years had a good deal to say about narrow band F.M., and its advantages in these days of crowded bands, there do not seem to have been many circuits described which enable the amateur to change quickly and easily to this form of modulation. With this in mind, we have designed and built a simple exciter which gives a narrow-band F.M. output of high quality with a minimum of constructional difficulty. The unit to be described uses four valves, and all that is needed to put its signal on the air is to connect its output to what may have been the crystal oscillator stage, or the low-powered buffer following the V.F.O., plug in the microphone to the jack provided, and talk! By the simple expedient of turning off the gain control to the speech amplifier, the unit may be used as a very stable V.F.O., with bandspread over the 80 metre band. If anyone is contemplating building a V.F.O., he could do worse than use the present circuit, for its frequency stability is that of the now well-known Clapp oscillator, and for the addition of a modulator and one audio amplifier stage, it is capable of giving substantially distortionless F.M. over a wide enough band for use on 80 metres. For use on the higher bands, the extent of the F.M. must, of course, be limited, since each frequency multiplication multiplies the deviation by a similar amount, but in this case all that is necessary is to turn down the audio gain control to a pre-determined lower setting, which gives correspondingly less F.M. at the fundamental frequency.

THE GENERAL ARRANGEMENT

In the top left-hand corner of the circuit we have a 6AC7, which is used as the modulated oscillator. This feeds its output to a second 6AC7, which is a broad-banded buffer, and has link coupling to the output terminals. Then we have an EF37, as a high-gain audio amplifier. It can be regarded as the microphone pre-amplifier, but it is hardly that, since no further A.F. amplification is needed! The EF37 feeds one half of a 6SN7-GT, connected as a cathode follower, and this feeds the audio signal into the grid of the Miller type reactance modulator, which is connected to the oscillator circuit and produces the frequency modulation. This is perhaps the simplest type of reactance modulator, and has no vices whatever. It is simple to tune up and to get going, and can be expected to be as trouble-free as the rest of the circuit.

THE OSCILLATOR CIRCUIT

The Clapp oscillator circuit, so called, is by now well enough known to need little description here. It is eminently suited to the production of an F.M. signal, since it is inherently exceedingly stable, which is a first requisite of an F.M. oscillator. This may sound a contradiction in terms, but it really is not, because apart from the intentional frequency shifts, giving the modulation, the frequency should be as stable as we can make it. Not only is the Clapp circuit inherently stable, in its own right, but it also has the possibility of connecting the modulator to it in such a way as to cause the least possible disturbance to the frequency stability.



This is effected by connecting the modulator, not, as in the ordinary type of F.M. oscillator, directly across the tuned circuit, but across one of the large coupling condensers which effectively tap the valve down the tuned circuit, thereby reducing the effect of varying valve capacities to a bare minimum. In the Clapp circuit, which is sometimes wrongly called "series tuned", the valve is coupled very lightly to the tuned circuit, and at points of very low impedance, so that if the reactance modulator is connected across cathode and ground, as here, the same advantages as the circuit possesses as an ordinary oscillator accrue for the F.M. modification too.

The reactance modulator circuit is essentially a simple one. In the circuit diagram, it consists of the left-hand half of the 6SN-7. The grid of this valve is capacity coupled to the cathode of the oscillator, and so receives a small input voltage from this point. In the plate circuit there is a circuit tuned to the oscillator frequency, and quite heavily damped by a 50k. resistor shunted across it. The modulator thus acts as an amplifier at the frequency of the oscillator. It would in theory have been possible to use a plain resistor as the plate load for this tube, but in practice this would not have worked so well, because the action of the modulator depends on the tube having some amplification at the radio frequency. It is well known that a triode resistance-coupled amplifier has little or no gain left at frequencies as high as 3.5 mc/sec., and so it is necessary to use the tuned circuit as the plate load impedance. It might be thought that this arrangement would oscillate, and so it would if the grid circuit were a high-impedance one, but because the grid is connected to a point of such low impedance, the feedback through the grid-plate capacity is so small that oscillation cannot occur.

Now when a triode has a resistive load in the plate circuit, and is amplifying, the input capacity is much higher than simply the sum of the grid-plate capacity and the grid-cathode capacity. In fact, it is much greater than this, and depends in a simple way on the amplification. The simple formula which gives the actual input capacity is:—

$$C_{in} = C_{g\text{-}c} + (G + 1)C_{g\text{-}p},$$

where C_{in} is the effective input capacity,
$C_{g\text{-}c}$ is the grid-cathode capacity,
$C_{g\text{-}p}$ is the grid-plate capacity, and
G is the amplification.

Thus, in an audio amplifier stage using, say, a 6J5 with a 100k. load resistor and having a gain of 14 times, C_{in} works out, according to the above formula, to 54.5 μμf. whereas the grid-cathode capacity is only 3.4 μμf. Since the effective grid input capacity depends on the gain of the circuit and not just on the valve capacities themselves, this gives a clue as to how this Miller effect, as it is called after its discoverer, can be put to use in a frequency modulator. If we make the amplification occur at the radio frequency of the oscillator, and vary the amplification by means of an audio signal on the grid, then the input capacity will vary too, and can be used as part of the oscillator's tuned circuit, in which case it will cause an electronic variation of the tuning capacity when the audio signal is fed in, giving the frequency modulation we want. The Miller effect frequency modulator is not often used these days because other circuits can give a greater linear frequency change, and so, wider frequency deviation. In the case of narrow-band F.M., however, this narrow linear sweep does not matter very much, because we are only interested

in a narrow deviation, and so can make use of the present simple circuit. The modulator is given fixed bias by means of a bleed from the H.T. line, and this bias can be adjusted to the right value to give the most linear frequency sweep. The value of the resistor R may vary somewhat with the tube used, and a method of finding the right value for it in any particular instance will be given later. The modulator tube has a grid leak of only 10k., since a low value was found to give the best linearity of frequency sweep. This means that the audio amplifier looks into an impedance of only 10,000 ohms, which is too low to enable a resistance-coupled stage to be fed in directly. Two ways of overcoming this are possible. The first, and perhaps most obvious method is to use a transformer in the plate circuit of the audio amplifier valve, but this is not the simplest or least expensive solution, for the following reasons. If a transformer is used, it will be necessary to feed it from either a small triode, such as a 6J5, or from a small power pentode, because it is not possible to transformer couple a voltage amplifier pentode unless a very special transformer were available. In any case, such transformers do not exist as stock lines, so that if a small triode were used with an output transformer having a ratio of about 2:1 step down, as would be necessary for correct matching, it would be essential to have a further voltage amplifier ahead of it. This would entail two valves and the transformer. But by utilizing the alternative scheme, illustrated here, the transformer is eliminated, and no further valves are used. The modulator is made one half of a 6SN7, leaving the other half free for use. This we make a cathode follower, which has a voltage gain of approximately 0.95, and can also feed the low-impedance grid circuit quite satisfactorily. Since the cathode follower virtually introduces no loss, and in addition to its low output impedance has a very high input impedance, we can use a high-gain pentode audio amplifier stage ahead of it. This stage will work under even more favourable conditions than usual, and will give somewhat higher voltage gain than is indicated in the resistance-coupled amplifier tables, because instead of working into a grid leak of about 500k., it is feeding an impedance of approximately 20 megohms. It is thus possible to get away with only one amplifier stage, excited straight from a low-level microphone. For example, in testing out the unit in the laboratory, a miniature crystal hearing-aid microphone was used with complete success. The audio circuit will thus have ample gain for almost any microphone that the amateur is likely to use. In any case, if a less sensitive mike is to be used, it will be a simple matter to add a low-gain triode amplifier stage as a pre-amplifier, and there will then be ten to 14 times as much gain as with the present set-up.

USE OF A BUFFER

It is always desirable to use a low-powered buffer stage between a V.F.O. and the transmitter proper, because however stable the oscillator, it is essential to reduce variable loading effects to a minimum. By the latter is meant that when the following stage is liable to be altered, as it probably will be when band changing, from a straight amplifier to a doubler, the loading on the oscillator will be different under the two sets of conditions, and could possibly have an effect on the oscillator frequency. The use of a low-powered buffer after the oscillator, therefore, has two desirable effects. First, it steps up the power output slightly. This is very necessary, especially with the Clapp oscillator circuit, because this oscillates very weakly, and produces very

small power output. Secondly, the loading on the oscillator is rendered constant at all times, irrespective of what the second stage after the oscillator is called upon to do. Here, we have indicated a tuned buffer, with a resistance-loaded plate circuit to broaden the response, and make adjustment to the tuning less necessary as one tunes over the band with the oscillator. However, if the output of the V.F.O. is to be fed into what was the crystal oscillator valve, used for the purpose as an extra low-powered buffer, it will probably be possible to get enough drive for this tube without tuning the second 6AC7 at all. If this is contemplated, it is suggested that a load resistor of approximately 5000 ohms be used instead of the tuned circuit. In this case, it will be necessary to have the unit close to the input stage of the transmitter, so that capacity coupling can be used from the buffer to the first valve in the transmitter. With the present set-up, the oscillator unit can be at any desired distance from the main rack, and link coupling used. This will usually be an advantage, since it will allow the frequency to be altered slightly without leaving the operating position, and also will enable the A.F. gain control and the microphone input to be right at the operating table. If it is found that the output of the unit falls off too much to enable the whole band to be covered without re-tuning L_2, it will be in order to decrease the value of the 20k. shunt resistor. This will reduce the output somewhat, but this will probably not matter at all.

CONSTRUCTION

This month's cover picture shows the upper-chassis construction of the prototype constructed in our laboratory. This chassis is 10¾ in. x 6 in. x 2½ in. deep. The layout is so simple that no chassis drawing has been given. A piece of 18-gauge sheet aluminium is bent up to form the mount for the tuning condenser and the baffle-shield round the coil L_1, which is mounted above the chassis, by a simple but ingenious method which gives great rigidity. The total length of the shield partition is eleven inches, the part parallel with the panel being four inches long, and the side pieces 3½ in. each. A half-inch flange is bent up for mounting, and when the whole is bolted to the chassis it makes a very rigid structure. The midget tuning condenser is mounted by a single ⅜ in. hole in the middle of the back portion of the shield, and the ends of the side pieces are placed flush with the back edge of the chassis. This leaves approximately 2½ in. between the panel and the shield, and this is plenty for installing a flexible coupler and the "works" of a slow-motion dial. On the right in the photograph are the two 6AC7s, with the oscillator valve nearest the back of the chassis. The other is, of course, the buffer. Immediately in front of this tube, on the front panel, is a connector from which the output is taken. The connector is of the Amphenol single-conductor type, as used for microphone inputs, and in a corresponding position on the other side of the chassis is another of the same kind, for the microphone input. On the left in the photograph are the remaining two tubes.

In the underneath photograph can be seen the lay-out for the rest of the wiring. Here, the oscillator and buffer are on the right, with the front of the chassis at the bottom of the photograph. Near the oscillator socket is a feed-through insulator, which takes the connection from the lower end of the coil (which is the grid end) through from the top down to the grid pin on the oscillator socket. The coupling condenser of 100 $\mu\mu$f. can be seen going from the feed-through to pin No. 4 on the oscillator socket. A point to note about the wiring of the oscillator circuit is that one of the mounting screws for the shield partition is used as a common earth point for the oscillator tube. This can be seen immediately in front of the feed-through insulator, and from it a wire is run straight to the shell pin on the socket. On top of the chassis, this same screw is used as an earth point for the tuning condenser. Although this is mounted on the metal partition, this is not relied upon for an R.F. earth, and instead, a wire is taken from the rotor's wiping contact down to a solder lug under the screw head. It is attention to small details like this that can make all the difference to the operation of R.F. equipment, for doing the earthing properly in this way, and not relying on the chassis for earthing ensures that as little R.F. current as possible flows through the chassis, and eliminates the cause of numerous somewhat "foxing" faults.

In the right-hand front corner can be seen the output circuit for the buffer stage, while in the left-hand back corner, as far away from it as possible, is the tuned circuit for the modulator plate.

Near the electrolytic condenser that can be seen in the middle of the back of the chassis can be seen a stand-off insulator. From this insulator a heavy bare wire goes off to the right to the cathode pin on the oscillator socket. Then on the other side, the 500 $\mu\mu$f. coupling condenser can be seen, going to the grid of the modulator valve. The stand-off is there merely as a tie-point, which will make the rather long connection between the two valves a strong and rigid one. Since this lead is part of the oscillator circuit it is essential that it be firm, otherwise handling of the controls, or the unit itself, may cause undesired frequency shifts.

In front of the chassis, mounted on the panel, can be seen the connectors for the output and the audio input, the audio gain control with switch, and on the other side, the stand-by switch. This latter has not been shown on the circuit diagram, but is merely connected in the 225v. regulated supply lead.

If the unit is to be used as a V.F.O. without N.F.M., the best way to do this is merely to turn off the audio input control. This leaves the modulator and audio amplifier running, which is desirable, for if the modulator were turned off there would be a slight shift in the frequency of the oscillator, and the calibration would be altered. It is for this reason that the bezel lamp and switch have been incorporated. They show that the volume control is turned right off, and that unintentional modulation cannot occur when the lamp is off.

COIL DATA

The oscillator coil, L_2, consists of 24 turns of 28-gauge enamelled wire, double-spaced on a 1¼ in. diameter former. The latter started life as a plug-in former, made of polystyrene, and of Australian manufacture. It was modified by cutting off the end with the valve pins, and fitting two solder lugs into the former itself. These lugs are of the type that end in a tubular rivet, and are pressed into an ⅛ in. hole in the former. However, before this is done, the mounting ring must be made. This is made from the mounting ring belonging to an Amphenol type valve socket, simply by filing it out until it will slip over the 1¼ in. former. The latter has a rim round what was the top, and this rim sits on the chassis, and is clamped by the mounting ring. The latter is attached to the chassis by means of two bolts through the existing mounting slots. Do not forget to make the mounting ring, and slip it over the former *before* the solder lugs are fitted!

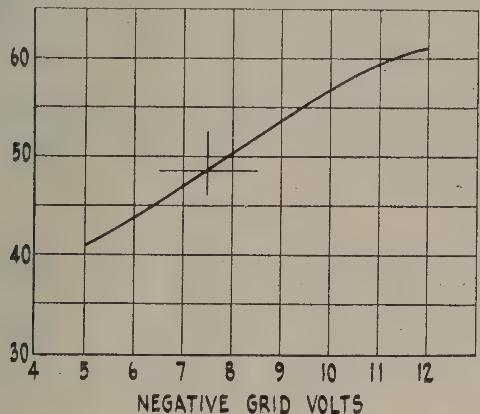
The amplifier coil, L_2, is made by winding 30 turns of 28-gauge enamelled wire on a ¾ in. former, close wound. The coupling loop, L_3, consists of three or four turns of the same wire about ⅛ in. from the H.T. end of the other winding.

The modulator coil, L_4, can be of the same dimen-

sions and number of turns as the amplifier plate coil. Alternatively, both these coils can be made from existing commercial coils. The one to use is one intended as the oscillator coil for the medium-wave range of an all-wave receiver. However, the home-made coils are cheaper, and just as effective, as well as being easy to wind.

TESTING FOR FREQUENCY DEVIATION AND LINEARITY

After a circuit like this has been built, it is desirable, though not essential, to carry out tests in order to make



Curve showing the frequency-shift characteristic of the unit. The vertical scale is in arbitrary units representing frequency.

sure that the frequency deviation is great enough, and that over the required frequency swing, the frequency deviation is a linear function of the audio input voltage. In order to do this, it is necessary to have an accurate means of measuring the frequency, and not every builder will have this. However, those who cannot perform the tests will not need to worry. The proof of the pudding is in the eating, and if the circuit is well-built, and uses the recommended circuit values, there is very little that can go wrong with it. However, for those who have the facilities, it is interesting and instructive to test the modulator fully, and so we will describe the process here. The gear needed is as follows: (1) An accurate beat frequency meter, or a direct-reading audio frequency meter; (2) a battery of about 18 volts; (3) a voltmeter (1000 ohms per volt) and a 10 or 20k. potentiometer. The procedure is then as follows:—

(1) The 200 -ohm cathode resistor of the modulator tube is short-circuited to ground.
(2) The grid R.F. choke is disconnected from the 1 μf. coupling condenser.
(3) The battery is connected across the potentiometer, and the positive terminal is earthed to the chassis.
(4) The voltmeter is connected from the moving arm of the potentiometer to earth, and the moving arm is connected to the now free input end of the R.F. choke.

It should now be fairly obvious what we are going to do. The scheme is to apply known D.C. voltages to the grid of the modulator, and for each voltage, measure the frequency. Then, when a number of readings have been taken, a curve can be plotted showing frequency against D.C. grid voltage. The curve will then show what part of the deviation characteristic is linear, and therefore the correct spot to bias the modulator, and also

how much linear frequency sweep can be had from the circuit, and how much peak-to-peak audio voltage is needed for a given amount of deviation. (In this country, the maximum allowable deviation for N.B.F.M. according to the regulations, is plus and minus 3 kc/sec.)

Thus, with the curve plotted in this way, we can tell everything we may want to know about the performance of the unit.

In order to measure the frequency with a good frequency meter such as the surplus BC211 wavemeters, or the LM series, all that is needed is to pick up the signal from the oscillator in the wavemeter, and to read each frequency in the usual way by zero-beating, and then reading the dial. If an A.F. direct-reading meter is used, such as is described elsewhere in this issue, a little auxiliary equipment will be needed. It will be a fixed-frequency oscillator of some sort, and a diode detector followed by some audio amplificatoin to bring the audio beat note up to approximately 1 volt amplitude. The auxiliary oscillator, and the output from the F.M. unit are both fed into the diode detector, and one or other of them is adjusted to zero beat. It is preferable to do this with the full 18 volts bias applied to the modulator valve. Then, as the frequency is varied by altering the battery voltage on the grid of the modulator, the shift in frequency of the modulated oscillator will show up as an audio beat note, whose frequency will be indicated directly on the frequency meter. Then to plot the curve, these readings are plotted against the D.C. grid voltage as before. It will be found that the best bias voltage (*i.e.*, at the centre of the most linear portion of the curve) will be 7.5, or thereabouts, and that at about 5 volts and 10 volts, the graph starts to show signs of

(Continued on Page 33.)

TUBE DATA:

RIG-BUILDER'S CIRCUIT GUIDE

PART II

Neutralizing condensers (NC) should have an air-gap 50 per cent. greater than that of the plate condenser. Maximum usable capacity of the neutralizing condenser should be somewhat greater than the grid-to-plate capacitance of the tube it is used with.

The wattage of the various resistors is not given. This is easily computed by I^2R, where I is the current through the resistor (grid current or screen current). Use a wattage rating which is approximately double the computed value, as a safety factor.

CIRCUIT A

The filament bypass condensers may be of the 600-volt paper type. The 0.001 μf. plate bypass condenser should have a voltage rating of twice the D.C. voltage for C.W. operation and three to four times the D.C. voltage for phone operation. The R.F. choke should be of the all-band type and be capable of handling the D.C. plate current.

CIRCUIT B

The circuit as shown is for phone operation only. If C.W. operation is desired, omit resistor R_2, and use a separate source of voltage on the screen grid as indicated in the table. Circuit B is used for tetrodes, beam power tubes, and pentodes. If the beam-forming plates of the beam tubes are brought to a pin connection, they should be connected to the centre-tap of the filament transformer. If the tube has a cathode connection, it should be connected to the ground. The suppressor grid in pentodes should also be grounded, unless the table indicates that a positive voltage is required. In the latter case a well-regulated source such as a battery should be used.

The filament bypass condensers may be of the 600-volt paper type. The 0.002 μf. plate bypass condenser should have a working voltage of twice the D.C. voltage for C.W. operation and three to four times the D.C. voltage for phone operation. The screen bypass condenser (0.005 μf.) should be rated at twice the screen voltage for C.W. work and three to four times the screen voltage for phone operation.

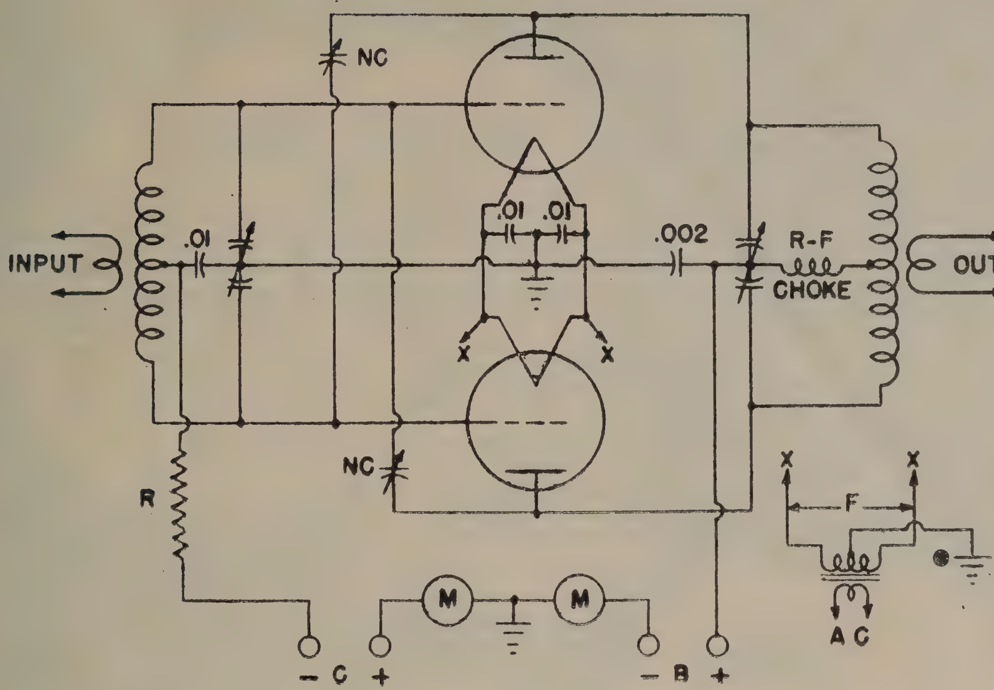
CIRCUIT C

This circuit is the push-pull version of circuit A. The same comments apply regarding bypass condensers. In addition, the 0.01 μf. grid circuit bypass condenser may be a 600-volt paper condenser for most circuits, unless the bias voltage is very high, in which case a 1250 or 2500 volt mica is preferable.

CIRCUIT D

Push-pull tetrodes, beam power tubes, or pentodes may be used in this circuit. As in the case with circuit B, the diagram shown is for phone operation only. For C.W. operation remove R_2 and supply screen voltage from a separate source. All remarks regarding beam-forming plates, cathodes, and suppressor grids pertaining to circuit B also apply to circuit D. Similarly, the comments on bypass condensers also apply.

PUSH-PULL TRIODE BUFFER OR FINAL

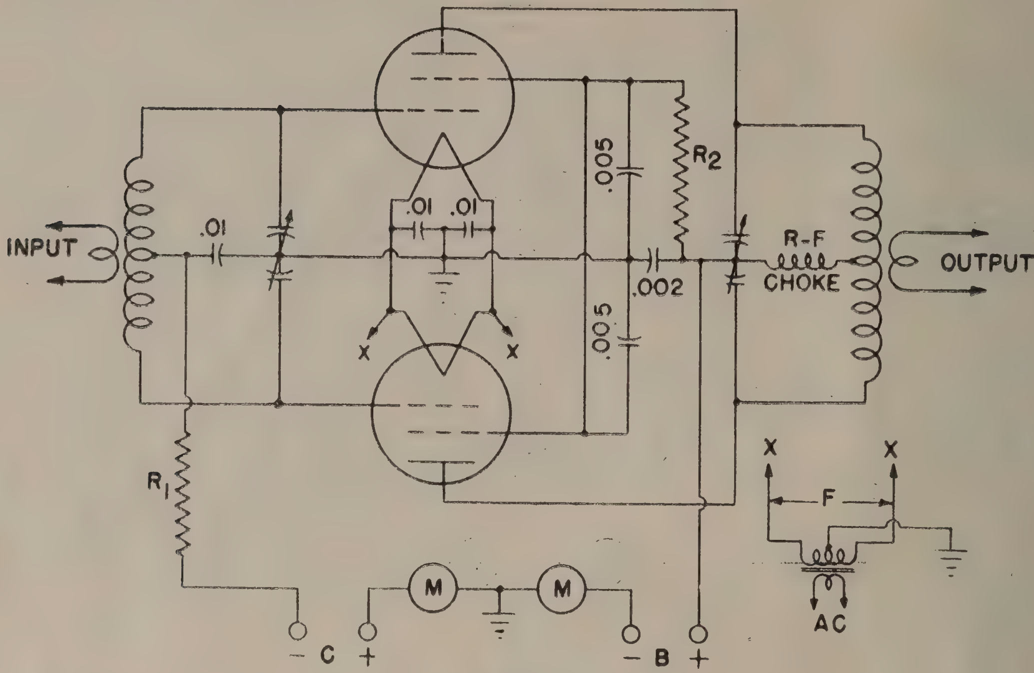


CIRCUIT C

Tube Type	Input watts		B		C		I_k ma		R ohms	F volts	Airgap (inches)	
	CW	PH	CW	PH	CW	PH	CW	PH			CW	PH
35T	500	336	2000	2000	45	105	90	46	1,000	5.0	.100	.250
100TH	990	732	3000	3000	75	215	102	52	1,250	5.0	.200	.500
203A	376	300	1250	1000	80	45	50	100	900	10.0	.070	.100
211	376	300	1250	1000	135	90	36	70	2,500	10.0	.070	.100
592	1000	790	2500	2500	80	200	90	90	1,750	10.0	.175	.375
805	600	400	1500	1250	45	70	80	120	750	10.0	.078	.144
806	1000	1000	2500	2500	250	200	50	80	5,000	5.0	.175	.375
810	1000	900	2000	1800	45	45	80	100	1,500	10.0	.100	.225
811	450	312	1500	1250	45	25	70	100	1,000	6.3	.078	.144
812	450	312	1500	1250	95	45	50	50	1,500	6.3	.078	.144
826	250	150	1000	800	35	65	70	70	500	7.5	.070	.084
838	376	300	1250	1000	45	45	60	120	750	10.0	.070	.100
1623	200	150	1000	750	45	75	40	40	1,250	6.3	.070	.084
8000	1000	1000	2000	2000	135	275	50	75	1,250	10.0	.100	.250
8005	600	476	1500	1250	90	160	64	56	625	10.0	.078	.144

All values are for two tubes.

PUSH-PULL TETRODE, PENTODE & BEAM POWER BUFFER OR FINAL



CIRCUIT D

Tube Type	Input watts		B		C		I_g ma		R_1 ohms	R_2 ohms PH*	E_{sg} volts		Airgap (inches)	
	CW	PH	CW	PH	CW	PH	CW	PH			CW	PH	CW	PH
2E24	80	54	600	500	20	15	6	6	5,000	20,000	195	180	.050	.070
2E26	80	54	600	500	15	20	6	6	5,000	17,500	185	180	.050	.070
4D21	1000	750	3000	2500	90	150	18	18	3,500	35,500	350	350	.200	.375
802**	66	40	600	500	45	0	4	4	13,500	8,500	250	245	.050	.070
803†	640	480	2000	1600	45	0	24	40	19,000	10,000	500	500	.100	.200
807	150	120	750	600	20	60	8	8	3,500	25,000	250	275	.050	.070
813	720	480	2000	1600	45	70	6	8	7,500	30,000	400	400	.100	.200
814	450	360	1500	1250	45	60	20	20	2,250	21,500	300	300	.078	.144
815‡	75	60	500	400	20	20	3	3	8,000	15,000	200	175	.050	.050
828 ◉	540	400	1500	1250	45	85	24	24	2,250	15,000	400	400	.078	.144
829B‡	120	90	750	600	20	35	12	12	3,000	13,000	200	200	.050	.070
832A‡	36	21	750	600	45	45	3	3	6,750	25,000	200	200	.050	.070
837**	60	36	500	400	45	0	9	10	3,750	6,500	200	140	.050	.050
1613	36	24	350	275	0	0	8	8	5,000	3,750	200	200	.030	.030
1614	60	46	375	325	0	0	4	4	10,000	5,000	250	245	.030	.030
1619	60	40	400	325	0	20	10	6	5,500	2,500	300	285	.030	.030
1624	108	76	600	500	45	45	10	6	1,500	12,500	300	275	.050	.070
1625	150	120	750	600	20	60	8	8	3,500	25,000	250	275	.050	.070

*Phone only; see text. **Suppressor grid voltage = +40 volts.
†Suppressor voltage of +40 for CW & +100 for phone.
‡Single tube operation.
◉ Suppressor voltage = +75 volts.
All values are for two tubes.

VIDEO I.F. AMPLIFIER DESIGN

By the Engineering Department, Aerovox Corporation

In modern radio communication and pulse ranging equipment, the necessity of transmitting and receiving a large amount of intelligence per unit time, or of handling wave forms which contain high frequency components, imposes difficult requirements upon the bandwidth of the circuits involved. In the radar system, for instance, the modulation of the transmitter by very short, rectangular pulses of energy, results in the R.F. output occupying a broad band or *spectrum* of frequencies. The width in megacycles of the band required for the transmission of such rectangular pulse signals is expressed, to a rough approximation, by:

(1)

$$\text{Bandwidth (mc.)} = \frac{2}{\text{Pulse length (Microseconds)}}$$

Thus, a radar transmitter being modulated by .5 microsecond pulses would occupy a band (exclusive of minor side bands) of 2 divided .5 or 4 megacycles. In television, the transmission of high-definition picture information

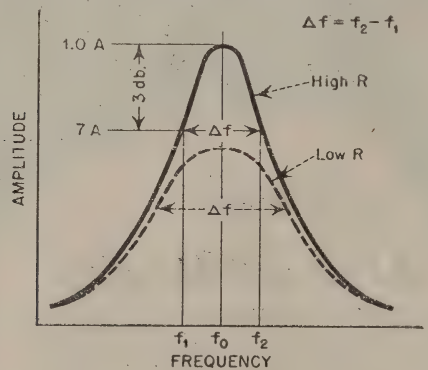


FIG. 1

consisting of several million elements per second, as well as synchronizing pulses and sound, requires the allocation of a 6 megacycle channel for each transmitter in operation.

In any such broad bandwidth system, if the receiver is to recover as much of the transmitted signal as possible, it must be capable of simultaneously accepting the entire band of frequencies transmitted and amplifying each equally. In the superheterodyne type of recevier, the satisfaction of this requirement greatly affects the design of the I.F. amplifier, since it is this channel of the receiver which determines the overall selectivity to a large extent. Fortunately, the design of broadband or "video" intermediate-frequency amplifiers has been greatly simplified by war-time research work. As a result, the design of high gain amplifiers capable of essentially "flat" band-pass characteristics as wide as 10 megacycles is relatively uncomplicated.

The bandwidth of an I.F. amplifier is taken as the frequency difference between points 3 db. down from maximum amplitude on each side of the response curve and is symbolized by Δf. See Fig. 1. In the simplest form of amplifier stage, which is the single-tuned circuit shown in Fig. 2, the bandwidth in megacycles is given by:

(2)

$$\text{Bandwidth } (\Delta f) \doteq \frac{1}{2\pi RC}$$

R = the total resistance shunting the tuned coil in megohms.

C = the total capacitance shunting the coil in $\mu\mu$f.

As this relation shows, the bandwidth of the single-tuned stage is inversely proportional to both the shunt capacity and the shunt resistance. In practice it is the resistance which is varied to control the shape of the response curve. The addition of "loading resistors" across the tuned circuits, common in television and other video I.F. circuits, broadens the response as is illustrated by the dotted curve in Fig. 1. Loading the resonant circuit lowers the circuit Q and thus reduces the maximum response or gain as is shown. The bandwidth at the new 3 db. point has been increased but the peak response has been sacrificed proportionately in favour of bandwidth. This demonstrates the important fact that the gain-bandwidth product of such an amplifier is constant. This means that a stage giving a gain of 10 over a bandwidth of one megacycle may also be made to deliver a gain of five at a two megacycle band-pass, or any other combination whose gain-bandwidth product (G × B) is equal to ten. The gain-bandwidth product, which is the accepted "figure of merit" of an amplifier stage, depends on the transconductance (gm) of the tube type used and the *total* distributed shunt capacity in the following manner:

TUBE TYPE	Trans-conductance (Micromhos)	Tube Capacity +5 mmf.	Gain-Bandwidth Product (Megacycles)
6AC7	9000	21	68.7
6AU6	5200	15.5	53.6
6BA6	4400	15.5	45.3
6AG5	5000	13.3	59.5
6AK5	5000	11.4	69.4

TABLE I

Since the gain-bandwidth product is inversely proportional to C, which includes the distributed wiring capacity as well as the tube interelectrode capacitances appearing across L, it is very important in circuit lay-out to reduce stray capacity to a minimum. In practical circuits using modern tubes, the total C may be limited to 10 $\mu\mu$f. Table I shows the G × B products for some frequently used tubes, allowing 5 $\mu\mu$f. for distributed circuit capacity.

Unfortunately, when single-tuned amplifier stages resonated to the same frequency (synchronously tuned) are cascaded, the overall band-pass does not remain that of the individual stages, but is reduced radically with the number of stages. Four stages, each four megacycles broad at the 3 db. point, when cascaded would thus have an overall band-pass of only 1.75 megacycles. This is evident from the fact that if the voltage gain at the centre frequency (fo) is 10, the gain at the 3 db. points is only 7.07. Upon amplification by a second identical stage, the gain at fo is 10 × 10 or 100, while the gain at the former 3 db. points is now only 7.07 × 7.07 or 50, which is 6 db. down in voltage. The bandwidth at the 3 db. points has been reduced to 64 per cent. of that for the single stage. Further amplifica-

tion by similar stages would result in the overall band-width being reduced to 51 per cent for a third stage, 44 per cent. for a fourth stage, 39 per cent for the fifth, etc.

In addition to the undesirable feature of rapidly decreasing pass-band for multiple stages, the synchronously single-tuned system does not satisfy the requirements of the television video I.F. since it is incapable of producing the flat-topped response curve required for picture reproduction. The shape of the video I.F. response which is accepted as the standard in television practice is shown in Fig. 3. An essentially "flat" band-pass of nearly 4 megacycles is required for high-definition picture reproduction on large-screen cathode ray tubes, although sets using small tubes may get along with much less. The gradual, nearly linear, decrease in the response at the picture-carrier end of the curve is intended to compensate for the presence in the transmitted signal of the first 1.25 mc/sec. of the lower side-band. (The rest is suppressed at the transmitter). When the picture-carrier I.F. frequency is aligned to the mid-point of this slope, the small portion of the *vestigal* lower side-band which is under the response curve is compensated for by the omission of a similar area from the lower 1.25 mc/sec. of the upper side-band. Therefore, the response to the lower video frequencies is made nearly equal to the higher ones, although derived partially from both upper and (vestigal) lower transmitted side-bands.

Considerable improvement over the performance of synchronous single-tuned amplifiers may be obtained by the use of multiple-tuned circuits. In a double-tuned, transformer-coupled stage such as is shown in Fig. 4, the coefficient of coupling (k) and the primary and secondary circuit Q's may be adjusted so that the response curve is essentially flat topped. Such maximally flat or "transitional" coupling occurs when the circuit Q's and the coefficient of coupling are related as shown in Fig. 4. The term "transitional coupling" is derived from the fact that the coupling is adjusted to the point of *transition* between the single and double-humped response curve. It will be recalled that, as the coupling coefficient of the tuned transformer is increased from a very small value, the curve of secondary current versus frequency changes from a small sharp peak when the circuits are under-coupled, to a broad double-peaked response when the circuits are over-coupled. (Dotted lines, Fig. 4). The coefficient of coupling of the interstage transformer may be determined by measuring the capacity values necessary to resonate the primary to a given frequency when the secondary is alternately open- and short-circuited. (Co and Cs respectively.) Knowing the ratio of these capacities; At the value of k corresponding to critical coupling, the transfer of energy to the secondary is maximum and the curve is flat-topped.

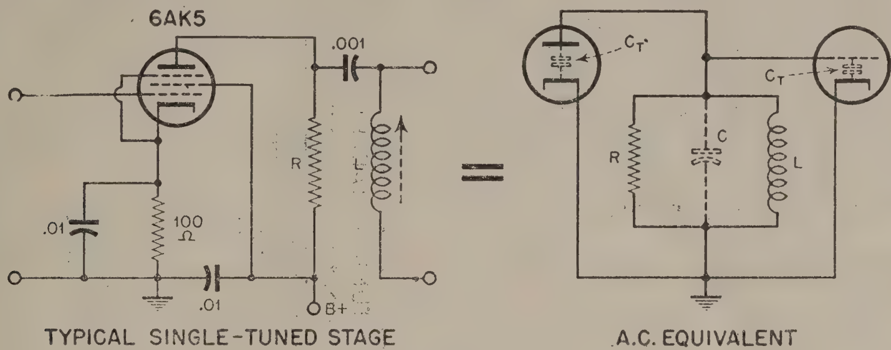


FIG. 2

(3) $$G \times B\ (\text{mc.}) = \frac{g_m}{2\pi C}$$

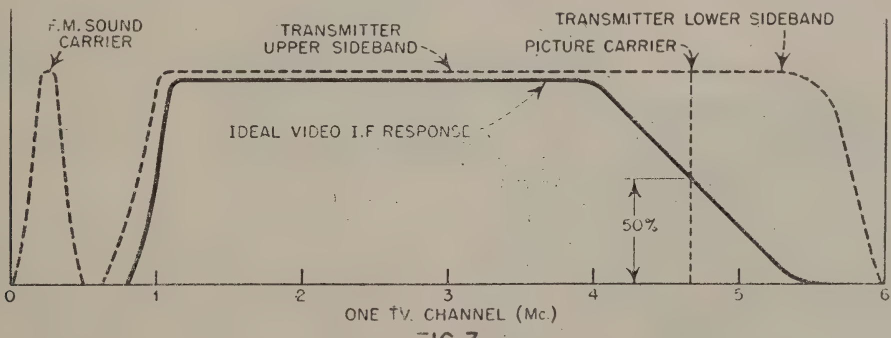


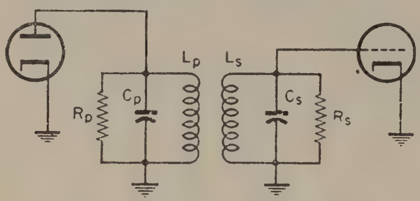
FIG. 3

(4) $$\text{Coefficient of coupling } (k) = \sqrt{1 - \frac{Co}{Cs}}$$

The response characteristic obtained in this manner is more nearly that required by the television video I.F. Furthermore, because of the more uniform response over the pass-band, the overall bandwidth does not decrease as rapidly when identical stages are cascaded as in the case of synchronous single-tuned stages. When two double-tuned, transitionally-coupled amplifier stages are

cascaded, the output bandwidth is reduced to 80 per cent. of the width of an individual stage. The corresponding figure for synchronous single-tuned stages is 64 per cent.

Further improvement in gain-bandwidth performance may be obtained by the use of more complicated interstage coupling networks. These include, double-tuned stagger damped, triple-tuned transformer-coupled, single-



EQUIVALENT DOUBLE-TUNED CIRCUIT

When: $Q_p = Q_s$

$$K = \frac{1}{\sqrt{Q_p Q_s}} \text{ for transitional coupling}$$

$$\Delta f = \frac{\sqrt{2}}{2\pi RC} \quad \text{where,} \quad C = \sqrt{C_p C_s}, \quad R = \sqrt{R_p R_s}$$

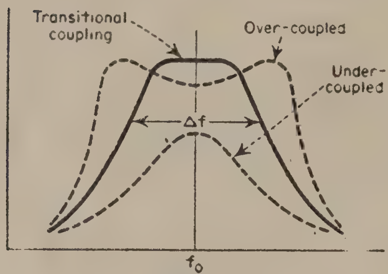


FIG.4

tuned inverse-feedback and complex filter-coupled stages. Most of these types are difficult to design and troublesome to construct and align, so will be discussed here in detail.

One type of band-pass amplifier which does retain the simpilcity of design and alignment of the synchronous single-tuned type, and yet overcomes most of its disadvantages, exists in the stagger-tuned amplifier. Wallman* and others have shown that if the successive stages of a simple single-tuned amplifier are adjusted to slightly different frequencies (staggered) throughout the desired pass-band, the composite response curve may be made flat-topped and the gain high. Furthermore, the design work requires only high school maths and a few simple tables, the construction done with common tools and the alignment may be accomplished in a few minutes with the aid of a spot-frequency signal generator and an output meter. The double-tuned and other more complex types previously mentioned require the use of a swept-frequency signal generator and an oscilloscope. Stagger-tuned systems are being used extensively in commercial television practice.

Since the individual stages of the stagger-tuned amplifier are merely the single-tuned type shown in Fig. 2, the design equations (2) and (3) which were presented in connection with the synchronously tuned amplifier may be used. These, used in conjunction with the table of stagger-tuning and bandwidth factors shown in Table II

*Wallman, Henry. MIT Radiation Lab. Report No. 524.

• STAGGER-TUNING TABLE •

Δf = Required overall bandwidth, f_o = Center frequency, $d = \frac{\Delta f}{f_o}$

NUMBER OF CIRCUITS	CIRCUIT FREQUENCY	CIRCUIT BANDWIDTH
Staggered-pair	$f_1 = f_o + .35\,\Delta f$ $f_2 = f_o - .35\,\Delta f$	$.71\,d\,(f_1)$ $.71\,d\,(f_2)$
Staggered-triple	$f_1 = f_o$ $f_2 = f_o + .43\,\Delta f$ $f_3 = f_o - .43\,\Delta f$	Δf $.5\,d\,(f_2)$ $.5\,d\,(f_3)$
Staggered-quadruple	$f_1 = f_o + .46\,\Delta f$ $f_2 = f_o - .46\,\Delta f$ $f_3 = f_o + .19\,\Delta f$ $f_4 = f_o - .19\,\Delta f$	$.38\,d\,(f_1)$ $.38\,d\,(f_2)$ $.92\,d\,(f_3)$ $.92\,d\,(f_4)$
Staggered-quintuple	$f_1 = f_o$ $f_2 = f_o + .29\,\Delta f$ $f_3 = f_o - .29\,\Delta f$ $f_4 = f_o + .48\,\Delta f$ $f_5 = f_o - .48\,\Delta f$	Δf $.81\,d\,(f_2)$ $.81\,d\,(f_3)$ $.31\,d\,(f_4)$ $.31\,d\,(f_5)$

After Wallman

TABLE II

(after Wallman) and a method of cutting the coils to resonance, are all that are needed to complete the design.

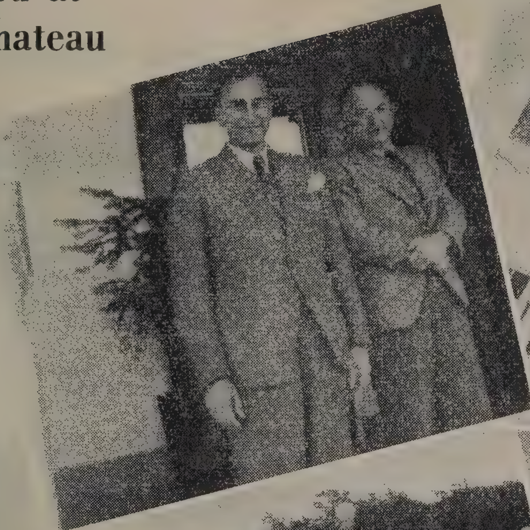
To illustrate the method of procedure, suppose that a video I.F. amplifier using 6AK5 pentodes is to have a uniform gain of 75 db. over a bandwidth of 4 mc/sec. centred at 24 mc/sec. Referring to Table I it is seen that the 6AK5 has a gm of 5000 micromhos and the total interstage capacity may be limited to 11 $\mu\mu$f. The gain-bandwidth product (Eq. 3) then becomes 5000/6.28 x 11 or 72.4 megacycles. If this stage "figure of merit" is divided by the required overall bandwidth of the amplifier, the result (18.1 or about 25 db.) is the mean stage gain available using 6KA5s. Therefore, three stages, properly staggered should be capable of providing the specified 75 db. gain. Table II gives the value of frequency and bandwidth to which each of the four coupling networks associated with the three stages must be adjusted to form a flat staggered-quadruple. In this example, the factor d, which is equal to the bandwidth divided by the centre frequency, is 4/24 = .166. Using this figure in Table II indicates the four circuits should be stagger-tuned to: 24.76, 23.24, 25.84, and 22.16 megacycles with the bandwidths adjusted to, 3.77, 3.56, 1.63, and 1.39 megacycles, respectively. Knowing the required bandwidths and the value of total C per stage, the values of the needed loading resistors may easily be found from the equation for the bandwidth of a single-tuned stage (Eq. 2). Solving for R in this equation yields values of 3845, 4060, 8900, and 10,400 ohms, in the order of decreasing bandwidth. In practice, the next higher stan-

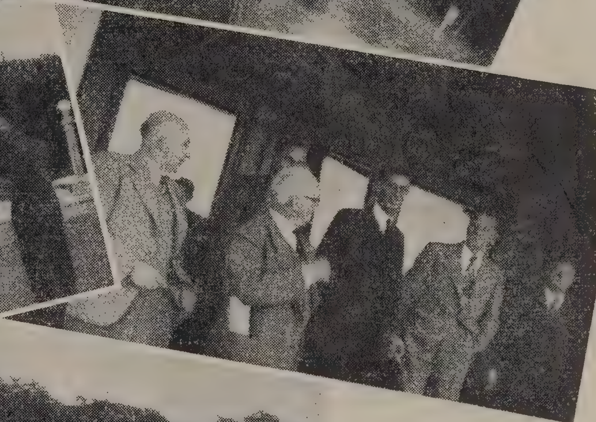
dard values of resistance may be used, since other tube and circuit resistances are in paralled with the loading resistors and lower the total effective value somewhat. The inductances required to resonate with 11 $\mu\mu$f. distributed circuit capacitance at the above stagger-frequencies may be determined by the use of a reactance calculator, a "Q Meter" where available, or by empirical formulas. Since additional capacitance is very detrimental to the gain-bandwidth product of the stage, the coils should be self-resonant with the circuit capacity or tuned with high quality powered-iron slugs.

When resistors and inductors corresponding to the values determined for R and L are inserted in typical single-tuned stages such as that shown in Fig. 2, and these stages are connected in cascade, the resulting stagger-tuned amplifier is non-critical to adjust and will compare favourably with more complex types in performance. The overall gain-bandwidth produce is better than a synchronously tuned amplifier of the same number of stages by a factor greater than two. Alignment is accomplished by connecting a standard AM signal generator to the input of the amplifier and an amplitude indicating device such as a voltmeter to the output. The signal generator may then be set to the recommended stagger frequencies in succession and the individual stage corresponding to that frequency peaked for maximum output response. Due to the isolating action of the tubes, there is virtually no interaction between stages while tuning. This is in sharp contrast to the procedure with double-tuned or triple-tuned circuits. In this case, a swept-frequency signal source and an oscilloscope must usually be connected to the input and output (respectively) of each stage in succession and the coupled circuits tuned and retuned until the desired response is observed on the 'scope. If adjacent-channel and sound carrier frequency "traps" such as are found in most television video I.F. amplifiers are incorporated in the single-tuned system, some slight tuning interaction may be noted.

Snapped at The Chateau

Radio Manufacturers' Conference 1950





Top left: New President and Vice-President take a bow.

Top right: The retiring President surveys the weather just prior to leaving.

Centre left: Members and wives intently watching a battery of cameras.

Centre right: Some members looking pleased wtih things.

Bottom: An exchange of views.

Regarded as a record attendance for Annual Conference, the following comprise the roll-call: W. J. Blackwell (Swan Electric Co. Ltd.); P. C. Collier (Collier & Beale Ltd.); L. H. Wright (His Master's Voice (N.Z.), Ltd.); W. D. Foster (Radio & Electronics (N.Z.) Ltd.); J. Carpenter (National Carbon Pty Ltd.); J. E. Rowe (Akrad Radio Corporation Ltd.); A. Chadwick (Westco Products Ltd.); T. R. Gobby (Dominion Radio & Electrical Co. Ltd.); N. Souper (Philips Electrical Industries of N.Z. Ltd.); D. T. Clifton Lewis (Radio (1936) Ltd.); F. W. Mountjoy (F. W. Mountjoy & Sons Ltd.); W. Meaghan (Sheffield Radio Ltd.); J. A. Cox (International Traders Ltd.); D. L. Wishart (Beacon Radio Ltd.); C. H. Roser (Radio & Electronics (N.Z.) Ltd.); B. Bookman (Goldberg Advtg. (Auck.) Ltd.); J. S. Burns (Collier & Beale Ltd.); G. Benson (Autocrat Radio Ltd.); T. J. F. Spencer (Akrad Radio Corpn. Ltd.); W. I. Cunninghame (H. W. Clarke (N.Z.) Ltd.); D. B. Billing (Turnbull & Jones Ltd.); R. Slade (Philips Electrical Industries of N.Z. Ltd.); G. A. Wooller (G. A. Wooller & Co. Ltd.); D. Clarke (Executive Officer Manufacturers' Federation).

The PHILIPS Experimenter

An Advertisement of Philips Electrical Industries of N.Z. Ltd.

No. 39: An Accurate Beat Frequency Meter for the H.F. Amateur Bands

PART III

SETTING UP AND OPERATION

The setting-up of the frequency meter is not at all a difficult process, since the built-in 1000 kc/sec. oscillator acts as a frequency standard, giving accurate check-points in several positions on the scale. Between the nominal band-end frequencies of 3.5 and 4.0 mc/sec., there are no less than eight points at which beats can be heard between the crystal oscillator and the variable oscillator. These are all due to the beating together in the mixer valve of signals which are harmonics of the crystal oscillator, with either the fundamental or the harmonics of the variable oscillator. Since the latter *is* variable, it is possible to adjust it for zero beat in each case, and then, when the dial reading has been taken, to plot a graph of dial reading against frequency. Eight points are quite enough for a smooth curve to be drawn, so that this meter has the unusual advantage that no additional equipment is needed with which to calibrate it. Naturally, some of the beats are very weak, so that for accurate zero-beating, additional audio gain may be necessary, but this can be had simply by feeding the output from the headphone jack to the input of an audio amplifier. Also, if necessary, the coupling between the crystal oscillator and the mixer valve can be tightened while calibration is in progress. This can be done by slightly increasing the value of the 5 $\mu\mu$f. coupling condenser at the plate of the crystal oscillator, and will have no effect on the frequency of either oscillator. However, it is unlikely that at the first switching on, the frequency range of the variable oscillator will be exactly correct. It will thus be necessary to effect some slight adjustment to the inductance of the tuning coil.

First of all, the meter should be switched on, and a check taken with an absorption wave-meter in order to see that the range is not too far out. There is no reason why it should be, especially if the coil-winding instructions have been followed carefully, but it is just as well to check, just the same—it is too easy to put one turn too few or too many on the coil, and this will make quite a difference, since the bandspread is very complete. If everything is working properly, it will be possible to receive signals from the variable oscillator on the absorption wave-meter, and it will also be possible to hear several beats in the headphones when the variable oscillator is tuned through its range. Most of these beats will be very weak, but there will be either two, or three loud ones. At this stage it might be as well to give a list of the beats that can be expected, and how they arise. The following table gives the oscillator harmonics concerned, and whether the beat will be strong or weak.

Beat Freq. kc/sec.	Harm. from Xtal Osc.	Harm. from Var. Osc.	Strength.
3,500	7th	2nd	Strong
3,600	18th	5th	Weak
3,666	11th	3rd	Strong
3,700	37th	10th	V. Weak
3,750	15th	4th	Strong
3,800	19th	5th	Weak
3,900	39th	10th	V. Weak
4,000	4th	Fund.	V. Strong

The four frequencies in bold type are those which produce the strongest beats, and which are used as check-points for setting the calibration of the meter from time to time just before a reading is taken. By providing extra gain, as suggested above, the others can be used as calibration points for drawing the calibration curve. However, they are too weak for normal use, because the frequency at which zero beat occurs cannot be accurately found, owing to the impossibility of hearing the zero beat properly. Since there is very little extra coverage with the circuit constants shown in the circuit diagram, it is likely that on first switching on, there will be only three of the strong beats audible, the remaining one being off the dial. In the case of the original model, the coil inductance turned out to be very slightly too large, and the frequencies, therefore, too low. As a result, the 3.5 mc/sec. beat was at about 25 on the 0–100 dial, and the 4.0 mc/sec. beat was off the dial altogether.

For initial setting up, the range switch should be in the position for 80 and 10 metres—that is, with both sections of the split-stator condenser in circuit. In addition, the panel fine-adjustment condenser should be set at half-scale, and left, until the inductance has been suitably adjusted.

Having found that both oscillators are working properly, and that some of the beats mentioned in the table can be observed, the first thing to do is to identify the 3.5 mc/sec. beat. To do this, the frequency of each of the loud beats can be checked with the absorption wave-meter, since this should be accurate enough to enable the operator to distinguish between 3.5, 3.66, 3.75, and 4.0 mc/sec. Having identified the 3.5 mc/sec. beat, it should be double-checked to make sure that it is not the 3.0 mc/sec. one. The latter may have come on the scale if the frequency is much too low, but it will be an extra loud one, because of the low order of the harmonics that make it—the third of the crystal oscillator and the fundamental of the variable one. Once the 3.5 mc/sec. beat has been identified beyond all doubt (and a calibrated receiver can be used to assist in the identification, as well as the wave-meter) what we have to do is to adjust the oscillator coil until it comes at the very end of the dial. In our own case, we had the 3.5 mc/sec. beat on a dial reading of 1.2, and the 4.0 mc/sec. point at 97.8, so that it can be seen that there is not much to spare at either end. However, by spreading the two bottom turns of the coil a little, quite large shifts in dial reading will be possible. It is preferable on this account to make only a very slight change in the position of the bottom turn for a start, so that the effect can be observed by re-tuning the 3.5 mc/sec. beat. If the first change is not enough, one can then estimate how much more movement is needed, and progress accordingly, until 3.5 mc/sec. is at, say, 2 on the dial. This done, the higher loud beats are checked for their dial readings, and in particular, a test is made to see whether the 4.0 mc/sec. beat is on the dial or not. If the zero beat is still just off the dial, it will be necessary at this point to proceed with great care, because any further decreasing of the inductance might put the 3.5 beat off the scale at the other end.

We will now assume, therefore, that 3.5 has been placed somewhere between 1.5 and 2 on the dial, and that the 4.0 mc/sec. beat can be heard, but that the zero beat cannot quite be brought on to the scale. Should this be so, it means that the bandspread is a little too great, and that in order to decrease the spread a little, the fixed capacity in the circuit will have to be decreased a little, while leaving the variable portion the same as before. The only way to do this is to find a 100 $\mu\mu$f. fixed condenser that is a little smaller than the one originally wired into the circuit. When this has been done, it will be found that the 3.5 point might be just off the end of the scale, and if so, the coil inductance will have to be increased again by squeezing up the turn that was previously spread out. This is done until 3.5 is once more on its original reading between 1.5 and 2 on the dial. Now, if the 4.0 beat is looked for, it will be found that it is on the dial, or at least, a little nearer to it than before. If it is not quite, a little careful juggling with the coil will tell whether both the 3.5 and the 4.0 beats can be accommodated on the scale. If they can, it does not matter how close they are to the ends of the scale, because the oscillator is very stable, and it can be assumed that they will not drift off, if the construction has been done rigidly enough. Throughout the whole of the adjustment process, the front panel adjusting condenser SHOULD NOT BE TOUCHED. If it is, the systematic procedure described will be ruined, and will become instead a hit-and-miss affair that will take much longer than necessary. Besides, if too much stretching and squeezing is done on the coil, it may become permanently loose, and should this happen, it will be necessary to re-wind it, and start all over again.

The procedure outlined above will in any case enable the variable oscillator to be set up correctly. When this has been done, and the coil turns doped in place as lightly as possible, the permanent calibration can be commenced. This part of the job is simplicity itself, and consists purely of setting the variable oscillator accurately to each zero beat, and carefully taking a dial reading, which is noted down. As mentioned earlier, extra amplification will be needed if the weak beats are to be accurately observed, but this is easily overcome. It should be pointed out, though, that for this to be done, the power supply to the meter should be well filtered, because it is difficult to observe zero beat in the presence of a lot of hum.

When the calibration points have all been checked, and their dial readings written down, all that remains is to draw the calibration curve. Since this is the final result, upon which the ultimate accuracy of the meter depends, it should be drawn to as large a scale as possible, to make it easily readable to fine limits, and should be drawn with a very sharply pointed pencil. This might seem self-evident, but the writer has seen some calibration curves that were drawn with a pencil point about four times as thick as the lines which divided the paper into squares! This sort of thing can never give an answer as accurate as the instrument is capable of.

(Continued on page 31.)

A Direct-Reading Meter for Measuring Audio Frequencies

The direct-reading audio frequency meter is not a new thing, satisfactory instruments of this type having been designed several years ago. The present circuit is an improvement on one developed in Australia in 1944, but the principle of operation is one with important applications in other directions. In its own right, too, the meter is an exceedingly useful one, and can be built successfully by anyone, without the aid of elaborate instruments.

INTRODUCTION

There are many purposes to which an audio frequency meter can be applied, and to any serious worker in the audio field it can be a very useful device. There are perhaps more uses for it, however, where radio frequencies are being dealt with, and anyone who has occasion to measure frequency at all often can find it a great time saver. Now there are many reasons for wanting to know radio frequencies with some accuracy, and there are reasons, too, for wanting to know small frequency *differences as well.* In all of these cases, the direct-reading audio frequency meter can be used, and will cut down the time taken to do the same things by more conventional means.

That this is true, will be readily appreciated by anyone who has had to do much audio frequency measurement by means of oscilloscope patterns. This method undoubtedly gives the answer, and the right one, if the operator is careful, but it is a time-consuming process and leaves quite a large margin for human error. The direct-reading meter, on the other hand, finds it difficult to give a wrong answer, and is exceedingly quick to use. As against these advantages, though, one has to be content with an accuracy of approximately two per cent., whereas the oscillographic method has a potential accuracy limited only by the time spent on taking an observation.

A further advantage of the direct meter, and one not lightly to be discarded, is that it is completely self-contained. The oscillographic method on the other hand, requires quite large quantities of auxiliary equipment, which is costly as well as slow to work. For all these reasons, therefore, the direct-reading meter is infinitely preferable to other methods, except in the few cases where an accuracy of two per cent. is not good enough. Let us take some examples of the type of thing that can be done with it.

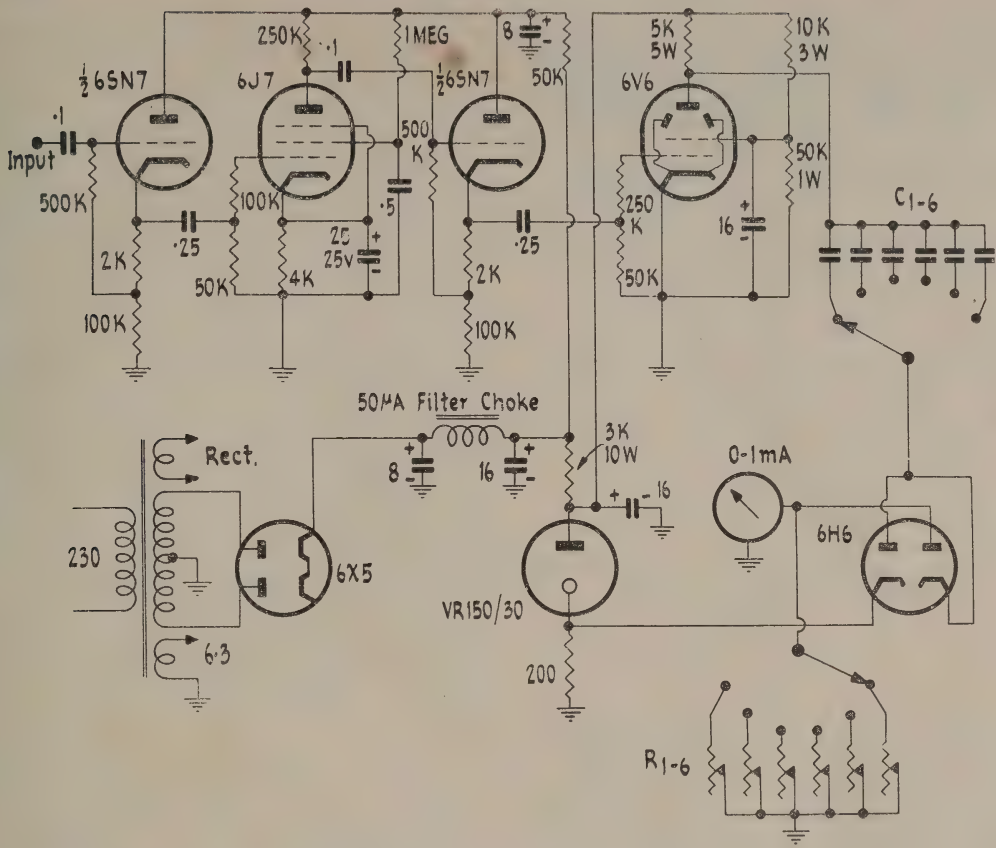
USES OF THE METER

Let us take first of all the case of straight-out measurement of radio frequencies. At the outset, we should make it plain that in taking a reading with the instrument we are about to describe, all that we have to do is to apply the audio voltage whose frequency we wish to know to the input terminal, turn the range switch to the position that gives a reading within the range of the meter, and read the frequency from the scale, which has the advantage of being a linear one.

Suppose then, that we are measuring a radio frequency by means of a precision frequency meter which provides crystal-controlled check-points every 10 kc/sec. By the ordinary methods, it is possible to say which 10 kc/sec. point is closest to the frequency being measured, but if we want an answer that is closer than this, it will be necessary to measure the beat frequency between the check point signal and the unknown frequency. For the sake of argument, let us take the case of a frequency between 3820 and 3830 kc/sec. Now if the actual frequency is, say, 3822.4 kc/sec., it will produce low-frequency beats with two of the signals from the frequency standard, namely, 2.4 kc/sec. with the 3820 signal, and 7.6 kc/sec. with the 3830 one, and both these frequencies will appear in the output of a detector which will be used to produce the beat frequencies. If the output of this detector is passed through a low-pass filter cutting off at 5000 c/sec., the higher of the two beats will be rejected, so that when the output of the filter is applied to the direct-reading frequency meter, it will read 2400 c/sec., Now since we have already identified the unknown signal as being between 3820 and 3830 kc/sec., and because we have used a low-pass filter to get rid of the high-frequency beat, we now know that the measured frequency is 3820 kc/sec. *plus* 2400 c/sec., or 3822.4 kc/sec.

In order to see what effect the accuracy of the A.F. measurement has on the overall accuracy of the R.F. measurement, we can calculate the accuracy of the latter. The secondary standard gives the frequency to within plus or minus 5 kc/sec. At the R.F. of 3822.4 kc/sec., this represents an accuracy of 0.131 per cent. Now, if we measure the A.F. beat frequency to an accuracy of 2 per cent., we have an overall accuracy of 48 c/sec., which is only 0.0012 per cent. of the radio frequency. Thus, by using the A.F. meter, we have increased the R.F. measurement accuracy from 0.13 per cent. to 0.0012 per cent.—just over a hundredfold.

Another use for the frequency meter is in testing F.M. equipment. For instance, suppose one has developed a circuit for giving narrow-band F.M. signals, which are allowed on certain amateur transmitting bands. When this is done, it is almost essential to test the unit for linearity of modulation, so that the limits for distortionless operation can be found. In the case of amateur N.B.F.M., we are limited to a frequency swing of plus and minus 3 kc/sec. Thus, our imaginary exciter would need to give linear modulation to wider limits than this so that we can be sure that under the output will be distortionless. Also, we need to know what gain setting will give the maximum allowable frequency sweep of 3 kc/sec. on either side of the centre frequency. For doing tests like this, the frequency meter is invaluable, because all one has to do to measure the frequency deviation for a given D.C. control voltage on the reactance tube, is to zero-beat the oscillator with a fixed frequency oscillator, in the absence of any control voltage, and then, with the frequency meter connected to the output of a detector, apply the D.C. control voltage. The meter then reads the audio beat frequency directly, and this is a direct reading of the number of cycles the modulated oscillator has shifted. In order to plot the performance curve of the modulator, all that has to be done is to take a number of readings of the frequency shift for a variety of D.C. control voltages. The graph is then plotted of frequency versus control voltage. Where this curve is a straight line, the modulation is linear and distortionless, so that to fix the right operating conditions for the reactance modulator, it is only necessary to find what D.C. grid voltage corresponds to the middle of the straight portion of the curve, and this voltage is the required bias for the modulator. Then, this having been fixed, the curve tells us the maximum grid swing that can be put on the modulator while still retaining linear modulation. If this is wider than the maximum allowable frequency swing, then all is well. It is also possible



Circuit of the frequency meter. The shunts, R_{1-6} can be wire-found potentiometers of 1000 ohms, while the condensers can be chosen to give the required full-scale ranges. Suggested values, with their ranges are:—

C = 0.08 μf.	0–100 c/sec.	C = 0.0027 μf.	0–3000 c/sec.
C = 0.027 μf.	0–300 c/sec.	C = 0.0008 μf.	0–10,000 c/sec.
C = 0.008 μf.	0–1000 c/sec.	C = 266 $\mu\mu$f.	0–30,000 c/sec.

to read from the curve the peak-to-peak A.F. input voltage required to give any desired deviation. This in turn enables the amount of audio gain needed to be estimated, since it will already be known what output voltage can be expected from the microphone it is intended to use.

These are only two examples of the usefulness of the audio frequency meter, but will serve to show what sort of thing can be done with its aid. Another useful purpose to which it can be put is the adjusting of a variable oscillator to known small frequency differences from a particular value, as, for instance, when one wishes to take selectivity curves, particularly on a very selective I.F. amplifier, such as one with a crystal filter. To do this, is very difficult with an ordinary signal generator, if not impossible, since the dial cannot be read to within a few thousand cycles, let alone a few hundred. With the aid of the frequency meter, however, and a detector and fixed oscillator, it is quite easy. The fixed oscillator is set to the desired centre frequency by zero-beating with the signal generator. Then, to take a reading at, say, 1000 c/sec. off resonance, one oscillator or the other (it does not matter which) is detuned until the A.F. frequency meter, attached to the output of the detector, reads an A.F. beat frequency of 1000 c/sec. In this way, very close adjustments of the frequency of an R.F. oscillator can easily be made.

CIRCUIT AND PRINCIPLE OF THE FREQUENCY METER

Having described some of the things that can be done with such a meter, let us go on to examine the principles underlying its operation. For the moment, we will dispose of the first three stages by saying simply that they are A.F. amplifiers, or rather two cathode followers with an amplifier stage between them. The reason for this particular set-up will be described later. Anyway, the 6J7 takes the audio signal and amplifies it, at fixed gain, until in its plate circuit there is an audio voltage of considerable magnitude—about 100 volts peak. The waveform will most likely be somewhat distorted, but we need not worry about this, because in the next stage we are about to distort it even more, and on purpose, too! Now the 6V6 is likewise a resistance-capacity coupled amplifier stage, and as can be seen by a glance at the diagram, is run at zero bias. Ordinarily, the 6V6, when used as an output valve, has to be biased to about —18 volts, and for distortionless output, the input signal is kept to a peak voltage a little smaller than this, or less, when full output power is not wanted. Here, however, the output from the driving stage is of the order of 100 volts peak, as mentioned above. As a result, the 6V6 is driven to cut-off and beyond for a large portion of the negative-going half-cycle, and during the positive half-cycle, is driven into grid current. The result is an

output waveform, something like that shown as the output on Fig. 1. Since the corners are almost square, and both sides, top and bottom, are almost straight lines, this is called a square-wave, to distinguish it readily from an undistorted sine-wave. The method described here is one of the standard methods of producing square waves, which are an essential part of the circuitry of television and radar. When the valve is operated in this way, it is really amplifying only during the steep sides of the square-wave, for at all other times it is either cut off, or passing heavy and constant current.

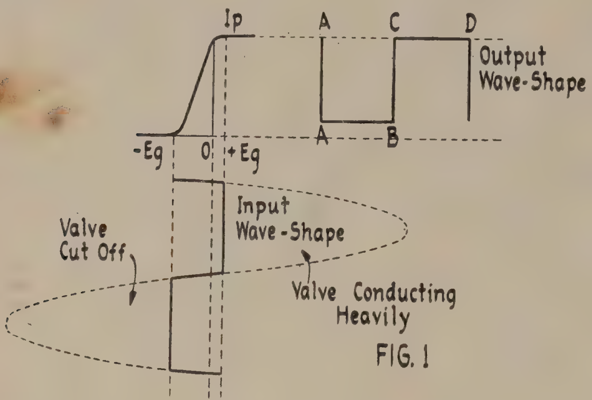


FIG. 1

It may not be immediately obvious why the bottom of the output waveform is flat, because this occurs during the heavily-conducting part of the cycle. The reason is to be found in the characteristic curves of the pentode or beam tetrode, and in the use of the large grid stopper resistor. The first point is illustrated in Fig. 2, which shows the characteristics of the 6V6, together with the load line for the 500-ohm plate load resistor. This shows that when the grid is sufficiently negative to cut the valve off, the plate voltage rises to the voltage of the H.T. line, and as long as the grid voltage is at cut-off or beyond, the plate voltage has this value. This explains readily enough why the positive half-cycle of the output voltage has the flat top, but it is not quite so easy to see why the same thing applies to the negative half cycle. First of all, if we look at the valve curves, it is seen that for an appreciable part of their length, all the grid voltage curves coincide, *i.e.*, at very low plate voltages. Thus, if the valve has a resistive load, and the grid is driven up to cathode potential, or even a little more positive, the plate will fall to the voltage represented by the point where the load line cuts the curve for Grid Volts = 0. At this point, the curves for positive grid voltages, were they given would lie very close to this one, indicating that even if the grid is driven positive, very little more change in plate current can occur, and therefore, very little further change in plate voltage. This action is assisted by the grid stopper, which sees to it that however positive the input voltage may be, the actual grid voltage never goes more than a small fraction of a volt positive. Thus, as soon as the grid starts to draw current, there is a large voltage drop in the stopper resistor, and this, together with the small resistance between grid and cathode once the grid is conducting, forms a voltage divider which does not allow the grid to go more than very slightly positive. In addition, because the valve amplifies considerably during the short periods in which the input voltage is crossing the valve's characteristic, the time that these periods last is very short indeed; so short are they, that the "on" and "off" periods are very nearly equal, and for all practical purposes are so.

Now, whatever the frequency that is fed into the input terminal, the same sort of waveform comes out at the plate of the 6V6. The only difference between the output at one frequency, and that at another, being the number of times per second that the waveform occurs. The circuit thus far, therefore, acts as a square-wave generator, producing square-cornered waves of the same amplitude and shape, irrespective of frequency, and differing only in that frequency. The 6V6 can indeed be likened to a switch, connected with a battery and a resistor (the load resistor) and operated at regular intervals, in such a way that the switch is open and closed for equal periods of time. The only difference between the 6V6 and the switch is that the former manages to perform the switching at very rapid rates, such as could never be obtained by a switch.

The next essential part of the circuit is the pair of diodes, together with the 0–1 ma. meter. This is known as a counter circuit, and produces a meter reading that depends directly on the number of switching cycles in a given time, or, in other words, on the frequency of the square-wave fed to it by the 6V6 .It works in the following way.

In order to simplify the explanation, the essential part of the counting circuit has been re-drawn in Fig. 3. This shows an input condenser, C, the two diodes, and the meter. Suppose that we suddenly apply the square-wave to the input side of the condenser, which we can imagine as uncharged beforehand. On the first positive

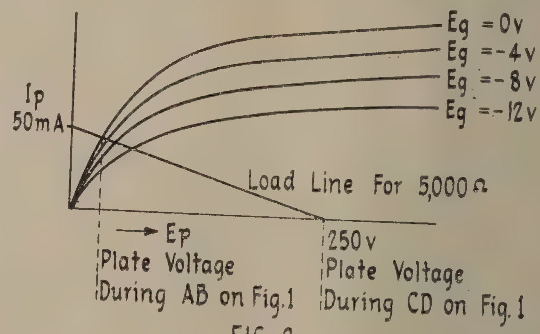


FIG. 2

voltage step, the diode V_1 conducts, enabling the condenser to charge up. Since the other diode, V_2 is connected in reverse, this cannot conduct during this half-cycle, because the current required to charge the condenser cannot flow through it. But, at the end of the positive half-cycle, there is a sudden drop in the voltage at the input side of the condenser, which therefore is caused to discharge. Now the discharge current cannot flow through V_1, but can flow through V_2, which it does, until it is discharged. After this, another positive step comes and charges the condenser again through V_1, and so on. The net result is that a pulsating, but uni-directional current flows through each diode, one working every positive half-cycle, and the other every negative one. It will be noted that we have assumed that at each voltage step, the condenser has time to charge or discharge completely before the next step occurs. This is important, and is one of the things that has to be looked after in designing the circuit values.

When a condenser is charged to a fixed voltage, the number of electrons, or in other words the total quantity of electricity flowing depends (*a*) on the capacity of the condenser, and (*b*) on the voltage to which it is

charged. Further, if the charging is done several times a second, the quantity of electricity passing each second will depend on both these things, and on a third also, namely, the number of times a second the charging takes place. But the quantity of electricity passing per second is the same thing as the current in the circuit, so it is possible to write a very simple equation connecting the voltage, the current through the charging diode, the capacity of the condenser, and the frequency. This equation is:—

$$i = C.V.f. \quad \ldots (1)$$

where i is the current in amps., C the capacity in farads, V the input in volts, and f, the frequency in cycles per second.

This equation is the theoretical basis on which the frequency meter rests as a measuring instrument, for all we have to do in order to convert the circuit of Fig. 3 into a frequency meter is to put a D.C. meter in series with either of the diodes, and suitably calibrate it. Either diode will do, because since the condenser is completely charged and completely discharged before every reversal, the current through the diodes must be equal. In practice, we are also interested in knowing what sort of current we can expect from a given circuit, so that we shall know how sensitive a meter movement we must use. Also, we must have some means of ensuring that whatever the frequency fed into the squaring circuit, the condenser will have time to become fully charged and discharged before the half-cycle of square-wave finishes. If this is not done, all the current will not have flowed into or out of the condenser, and the meter reading will no longer be proportional to the frequency. Another practical consideration of some importance is that of knowing how high a frequency the circuits can handle, and what, if anything, causes the circuit to have an upper or lower frequency limit, beyond which it does not work properly. All these points will be discussed in the next section.

PRACTICAL CONSIDERATIONS

The answer to the first question is given partly by equation (1), above. For instance, we know that if we take a 6V6 and give it a plate load resistor of 5000 ohms, it will give a square-wave output of approximately 125 volts if the H.T. voltage is 150. Secondly, we can put in a likely value for the capacity, C, say 0.01 μf. Then

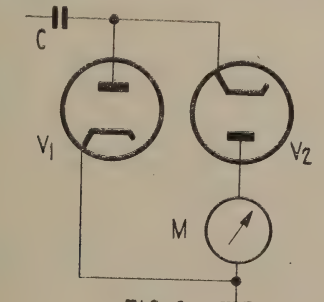


FIG. 3

all we have left is the current, and the frequency. If we fix the current at 1 ma., a convenient value, and substitute in the equation the values shown, we find that the frequency that would give the 1 ma. from a 125 volt square-wave, through a condenser of 0.01 μf. is 800 c/sec. This means that with the circuit constants shown, a condenser C of 0.01 μf. would give a full-scale reading of 800 c/sec. Similarly, if the capacity is divided by 10, making it 0.001 μf., the range of the

(Concluded on Page 48.)

The History of the World-Famous "HIS MASTER'S VOICE"

TRADE

MARK

The original picture was painted nearly 50 years ago by Francis Barraud, R.A. Mr. Barraud's brother had a fox-terrier named Nipper, extremely loyal to his master, and inclined not to be over-friendly with anyone else.

Mr. Francis Barraud, shortly after his brother's death, suggested one day that he would like to take Nipper for a walk, and, to his surprise, Nipper immediatel yattached himself to him. They became such fast friends that Mr. Barraud eventually took Nipper to his own home, and there he remained throughout his little life.

At that time Mr. Barraud was the owner of a small phonograph, of the type that employed wax cylinder records, and when he played these records he noticed the peculiar interest which Nipper took in the sound that came from the trumpet. He would prick up his ears immediately the phonograph began to talk, listening intently until the record had ceased playing. Watching him one day, Mr. Barraud conceived the idea of putting Nipper and the phonograph on canvas and giving it the title of "His Master's Voice."

His first effort, consequently, was a picture in which the old-fashioned cylinder phonograph was shown standing in front of Nipper. He took it to a company then prominent in the sale of wax cylinder phonographs to see whether any were interested enough to acquire it. They did not seem at all impressed by the originality and beauty of the picture, but asked for time to think it over. Mr. Barraud was keenly disappointed, and recounted his non-success to an artist friend, who suggested that the picture might be brightened up by painting a brass horn in place of the black horn which was issued on phonographs of that period. Mr. Barraud had never seen a brass horn, and, asking his friend where one could be obtained, he was told that there was a little company in Maiden Lane off the Strand, called The Gramophone Company, which might possibly lend him one.

And so, on a very memorable day in September, 1899, Mr. Barraud came into the little office of the then infant Gramophone Company in Maiden Lane and asked for the loan of a brass horn. This somewhat unusual request brought forth explanations, which resulted in Mr. Barraud showing the manager, Mr. William Barry Owen, a photograph of his picture, and in Mr. Owen's immediate request to see the painting itself. The painting, which was then still in the hands of the hesitating phonograph company, was eventually refused and returned to Mr. Barraud, who at once brought it to Mr. Owen, with a suggestion that he could easily paint out the phonograph and paint in a gramophone. It took only a short time to do this, and the original picture then entered into thepossession of The Gramophone Company. This original, which now hangs in a special recess over the fireplace in the oak-panelled Board Room of the Company's Head Office at Hayes, still shows traces in relief of the marks of the brush outlining the old wax cylinder phonograph.

From the moment of the acquisition of the picture by The Gramophone Company, its unique charm became evident. It was instantly popular. Photogravure copies were made and distributed by thousands, and were framed and proudly hung as works of art in the homes of England. Its continuing success led the Company and all of its associated Companies throughout the world to adopt it as the mark of their goods, and as all of these Companies prospered through the high quality of their products, so the new mark, "His Master's Voice," rapidly became the symbol of the supremacy of the Gramophone Company's goods.

The use of the mark by these various allied Companies was, of course, gradual, but in time every advertisement of importance contained a replica of the little picture of Nipper and the gramophone, as well as the title, "His Master's Voice," which Barraud had given to his picture.

New Zealand Representatives:

HIS MASTER'S VOICE (N.Z.) LTD.

118-120 WAKEFIELD STREET - - - - - - - - WELLINGTON

The Philips Experimenter

(Continued from Page 25.)

When drawing the curve, the checked points should be put in either with a minute dot, so small that it is hard to see, or else by means of a very fine cross, with the exact point where the pencil lines cross each other. The latter method is preferable, because in drawing the curve through the points, the intersection of two fine lines can be judged more accurately than the position of a single dot, unless the latter is so small as to be almost invisible.

Another point about drawing the curve is that the temptation to sketch it in freehand should at all costs be resisted. The curve will be found to be a very shallow one, although it will certainly not be a straight line, and the only way to draw it accurately through the plotted points is to use a French curve, which is a drawing instrument with a series of smooth curves on it, that can be matched up with the plotted points. In using one (and it would be well worth buying one for the purpose) the trick is to find by trial a part of it that will pass through as many as possible of the points, and then use it as a guide for the pencil. It is unlikely that one portion will fit *all* the plotted points so that two or more separate parts have to be used for different portions of the curve, and when this is done, it is necessary to see that the different parts used blend smoothly into each other. Several trials can be made, because graph paper is cheap, and it is worth while spending a bit of time and trouble over the final curve.

USING THE CURVE

We will assume that the frequency meter has been constructed and calibrated, and that we are in possession of a pretty-looking calibration curve. How do we use it to measure the frequency of an unknown signal? The answer to this question depends largely on what sort of signal we have to measure. That is to say, whether it is one from an oscillator or other source close handy, as one in the transmitting shack with the frequency meter, or whether it is one picked up by the receiver from a considerable distance. In each case, the technique is to zero-beat the signal with the variable oscillator or one of its harmonics, after which the frequency is read from the calibration curve. In the case of the strong local signal, the detector and amplifier within the frequency meter are used to observe zero beat in the ordinary way, but when a distant signal is being measured, the receiver is used as the indicator. This is done by coupling the output of the variable oscillator to the aerial terminal of the receiver. This has no effect on the frequency of the variable oscillator, because of the isolation provided by the electronic coupling within the ECH21 mixer valve. Since most communications receivers are very sensitive, only a very small signal is needed, and the stray coupling between the oscillator and the aerial terminal of the meter will be enough to provide an output great enough for beating with the incoming signal in a large number of cases.

Another use to which the crystal oscillator of the meter can be put is in calibrating the dials of receivers. Its harmonics, spaced by one megacycle intervals, can be received by the set to be calibrated, and if on any range, one of the oscillator's harmonics is identified, the others can be named simply by counting.

USE OF THE ZERO-SET CONTROL

This control is used to set the calibration of the meter immediately before a measurement is to be taken. The exact dial readings for the main check-points are known, having been taken when the meter was calibrated. Now, due to the effect of temperature variation, the variable oscillator will not hold its calibration indefinitely, and if no adjustment of the frequency were provided, there would be little use in having the crystal oscillator there as a calibrating source. As it is, however, the dial of the meter can be set to the exact reading at which it was originally calibrated for one of the check points. The crystal oscillator is then turned on, and the panel control is adjusted until zero beat is heard. We then have the dial at the correct setting, and the frequency exactly right. When this is done, the minute drifts have been taken up in adjusting the panel trimmer, and for the time being, the calibration is as good as new. The question may now be asked, "Which check-point is the one to use, and does it matter at all which is used?" The answer is simply that the right check-point is the one nearest to the frequency of the unknown signal. This gives the smallest residual error, for because the error drift cannot be removed entirely, but only reduced very much, by the above-mentioned procedure, the residual error will be least the less the dial has to be moved after the check-point zero-beating has been done. If the frequency check is to be made exactly at one of the check-points, the crystal oscillator can be turned on while checking is in progress, giving an extra beat that can be used.

Autocrat

DOUBLE-UNIT AUTO-RADIO ★

This is the third of the series of advertisements featuring circuits, etc., of Autocrat Car Radio. The previous issues covered the Tuning Unit and Six-valve Speaker Units.

Designed to fit any make of car simply and with a minimum amount of space. Made in two units, consisting of a small tuning unit of high efficiency connected by a special cable to a 6-in. speaker unit and the power supply.

CURRENT CONSUMPTION

The current consumption of Autocrat Car Radios is remarkably low, and provided battery is in normal condition no strain will be placed on the electrical system.

Six-valve models: Six-volt 4.2 amps.; Twelve volt 2.5 amps.
Eight-valve models: Six volt 4.8 amps.; Twelve volt 2.8 amps.

CONNECTIONS

Connect the tuning unit to the speaker unit by means of the cable supplied. Connect the power supply lead from the tuning unit to the ammeter or any suitable battery connection. Connect aerial to receiver by means of bayonet plug on side of tuning unit, using a shielded aerial lead.

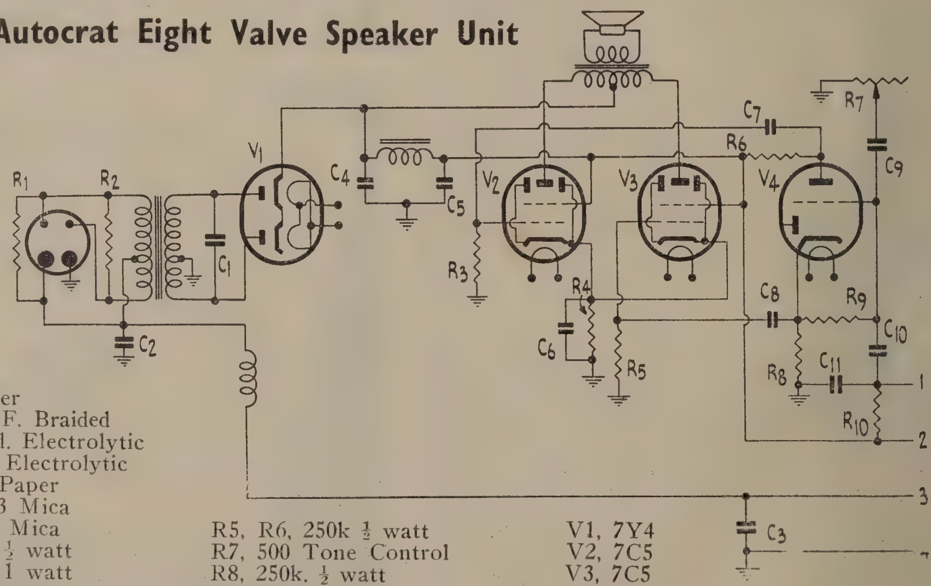
NOISE SUPPRESSION

A distributor suppressor must be fitted in the high-tension lead between the ignition coil and the distributor as close to the distributor as possible.

ALIGNMENT OF AERIAL

Switch on the receiver and allow to warm up, tune to weak signal between 1200 and 1400 kilocyles and peak the aerial trimmer to give maximum performance.

Autocrat Eight Valve Speaker Unit



C1, 0.01 Buffer
C2, C3, 0.5 R.F. Braided
C4, C5, 8 mfd. Electrolytic
C6, 25 mfd. Electrolytic
C7, C8, 0.02 Paper
C9, C10, 0.003 Mica
C11, 250 PF. Mica
R1, 100 ohm ½ watt
R2, 200 ohm 1 watt
R3, 250k. ½ watt
R4, 450 ohm 1 watt

R5, R6, 250k ½ watt
R7, 500 Tone Control
R8, 250k. ½ watt
R9, 10 meg. ½ watt
R10, 250k. ½ watt

V1, 7Y4
V2, 7C5
V3, 7C5
V4, 7C6

R1 not applicable to 1950 models.

Vibrator socket shown from top.

Manufacturers:

AUTOCRAT RADIO LIMITED

PHONE 48-130 - - - - - - - - 118 VICTORIA STREET, AUCKLAND

Sole New Zealand Distributors: G. A. WOOLLER & CO., LTD., AUCKLAND

F.M. Exciter

(Continued from Page 14.)

curvature, flattening out well before cut-off and zero bias are reached respectively.

AMOUNT OF FREQUENCY DEVIATION

In performing the original development work on this circuit, it was found that with the modulator tube's grid-plate capacity alone, the frequency swing for linear deviation was not wide enough, and for this reason a simple modification was made which is shown on the circuit. The condenser C, of 15 $\mu\mu$f., was added to the grid-plate capacity. Doing this amounts to making a valve with an abnormally large grid-plate capacity, for as far as the signal is concerned, it cannot tell whether the capacity it encounters is inside the tube or external to it. The result in practice is that instead of having to write 3.4 $\mu\mu$f. in the formula for the grid-plate capacity, we write 18.4, with a large consequent increase in the Miller effect capacity. Not only does the input capacity become very much greater, but so also does the variation of it, produced by applying signal to the modulator. As a result, a much larger linear frequency deviation is obtained.

USE OF A REGULATED POWER SUPPLY

It will no doubt have been noticed that the H.T. supply for the modulator and oscillator is specified as 225v., regulated. This is not really essential as far as the oscillator itself is concerned, but is a "must" for the modulator valve. This valve's gain will vary widely with changes of H.T. voltage, so that H.T. drift, caused by changes in line voltage will cause the centre frequency to change. The regulated power supply obviates this, and it should be remembered that any direct means of producing F.M., whether narrow or wide, will suffer in the same way if the modulator's power supply is not regulated. Accordingly, the power supply should contain a VR150 and a VR105 in series, to supply the 225v.

ADJUSTMENT FOR USE

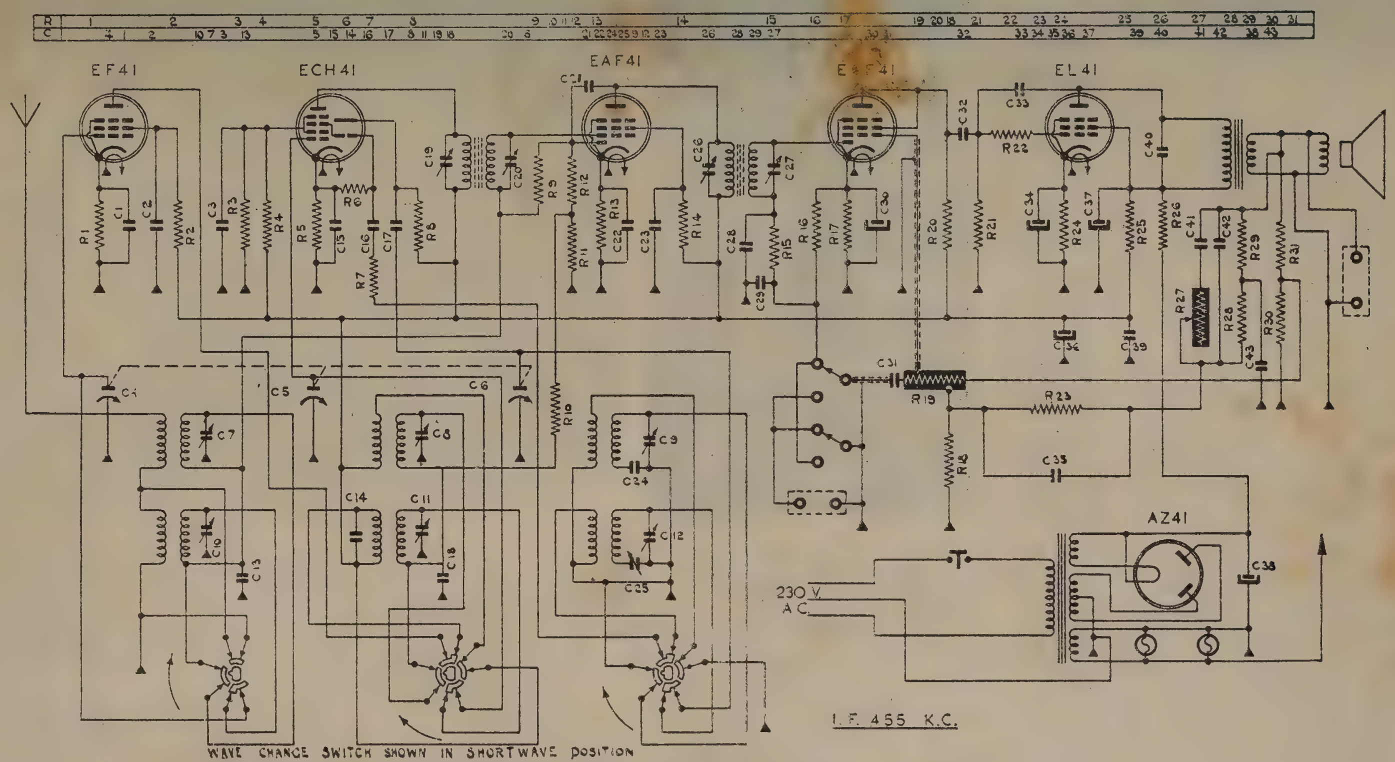
In this country, the band available for N.B.F.M. on 80 metres is from 3700 to 3800 kc/sec. This is fortunate in one way, because if the band were a little wider, it would be necessary to bring the tuning control for the modulator plate circuit out to the front panel. In practice, however, it is recommended that a spot frequency be chosen within the band, and all N.B.F.M. working done on this frequency. This will enable the modulator tuned circuit to be peaked up exactly for this frequency, thereby obtaining optimum results there, with little effect occurring if the operator wishes to QSY a few kc. on either side of this spot. The easiest way to set up the modulator tuning is to first set the oscillator to the desired carrier frequency, and then couple a sensitive absorption wavemeter as loosely as possible to the plate circuit of the modulator. Then, the tuning is peaked up for maximum output from the plate circuit of the modulator. Before this is done, however, the resistor R will have been adjusted to the value which gives the best operating point for the modulator. In the absence of a performance curve, obtained as described above, it will be sufficient to set the cathode voltage of the modulator tube to exactly 7.5 volts.

Once the modulator plate circuit has been tuned up, there is nothing to do but connect up the mike, and go on the air!

A SUITABLE RECEIVING ATTACHMENT

In an early issue it is hoped to describe a small unit which can be attached to any receiver to give distortionless reception of narrow-band F.M. signals. This unit, it is expected, will be fed from the 455 kc/sec. I.F. channel of the receiver, and will give enough audio output to be fed back into the set again at the grid of the first audio amplifier. It is hoped to make use of the diode counter-circuit type of discriminator, since this has no critical adjustments, and once the circuit is designed, will stay in alignment for ever, because there are not tuned circuits attached to the discriminator to get out of line and spoil the proper operation of the F.M. detector. With this, and the present unit, amateurs should have all the "gen" to enable them to transmit and receive N.B.F.M. signals of high quality, at relatively low cost, and without critical adjustments of any sort.

FOR THE SERVICEMAN—THE MULLARD MODEL 659



C1 .05 MFD. 400v. paper
C2 .01 MFD. 400v. "
C3 .01 MFD. 400v "
C4, C5, C6 10—440 MMFD. 3 Gang Tuning Condenser
C7, C8, C9 3-30 MMFD. S.W. Air Trimmers
C10, C11, C12 3-30 MMFD. B.C. Air Trimmers
C13 .05 MFD. 400v. Paper
C14 100 MMFD. Ceramic
C15 .05 MFD. 400v. Paper
C16 50 MMFD Silver Mica
C17 150 MMFD Ceramic
C18 .05 MFD. 400v. Paper
C19, C20 I.F. Trimmers in Can
C21 10 MMFD. Ceramic
C22 .05 MFD. 400v. Paper
C23 .01 MFD. 400v. Paper
C24 .004 S.W. Padder
C25 B.C. Padder
C26, C27 I.F. Trimmer in I.F. Can
C28 100 MMFD. Ceramic
C29 100 MMFD. Ceramic
C30 25 MFD. 25v. Electrolytic
C31 .05 MFD. 400v. Paper
C32 .02 MFD. 400v. Paper
C33 100 MMFD. Ceramic
C34 25 MFD. 25v. Electrolytic
C35 .02 MFD. 400v. Paper
C36 20 MFD. 400v., C37 40 MFD. 400v., C38 40 MFD. 400v. Triple Electrolytic.
C39 .25 MFD. 400v. Paper
C40 .0047 MFD. 400v. Paper
C41 .02 MFD. 400v. Paper
C42 650 MMFD. Mica
C43 .01 MFD. 400v. Paper

R 1 330 ohms. ½w. carbon
R 2 100K ½w. carbon
R 3 47K ½w. carbon
R 4 .25K ½w. carbon
R 5 220 ohms. ½w. carbon
R 6 22K ½w. carbon
R 7 270 ohms. ½w. carbon
R 8 25K ½w. carbon
R 9 2.2 meg. ½w. carbon
R10 2.2 meg. ½w. carbon
R11 1 meg. ½w. carbon
R12 470K ½w. carbon
R13 330 ohms. ½w. carbon
R14 100K ½w. carbon
R15 68K ½w. carbon
R16 1 meg. ½w. carbon
R17 2200 ohms. ½ w. carbon
R18 22K ½w. carbon
R19 2 meg. Vol. Control with Tap
R20 100K ½w. carbon
R21 470K ½w. carbon
R22 22K ½w. carbon
R23 270K ½w. carbon
R24 150 ohms. 1w. carbon
R25 2200 ohms. 3w. W.W. Bootlace
R26 900 ohms. 8w. carbon
R27 .5 meg. Tone Control
R28 47K ½w. carbon
R29 6000 ohms. ½w. carbon
R30 27 ohms. ½w. carbon
R31 100 ohms ½w. carbon

TRADE WINDS

NEW ZEALAND RADIO AND TELEVISION MANUFACTURERS' FEDERATION

A Report on Executive Action Taken Since the Annual Conference of the Federation

Since the Federation's annual conference, which is reported elsewhere in this issue, the Executive has been very active in pursuing the policy laid down at the conference. A number of important matters have been dealt with, and the following résumé has been supplied by Mr. Ralph Slade, the Federation's publicity officer.

(1) 1951 IMPORT LICENCE CUT OF 25%

On Wednesday, 8th November, the executive met the Import Advisory Committee, and a very full and frank discussion took place. The executive is not unhopeful that some relief might be forthcoming as a result of these talks.

(2) TELEVISION

The Executive met the Minister of Broadcasting (Hon. F. W. Doidge) on Thursday, 9th November, and presented its submissions on TV in New Zealand. The interview developed into a fairly lengthy one, and was particularly frank and open. The Executive were impressed by the Minister's obvious enthusiasm, and by his desire to have early action taken by his technical advisers. The Minister was good enough to promise the Executive that the Government will work in close co-operation with the industry on all matters pertaining to TV. He was also very concerned that any of his previous statements may have been misconstrued by the public, and stated that he would immediately make another public announcement, with particular reference to the essential differences between TV and sound broadcasting, so that the public mind is disabused of the impression that TV will displace sound sets. That statement was made in the press on 11th November.

Mr. T. J. F. Spencer, the new President of the Federation, replied in the press on 15th November, and suitably thanked the Minister for his clarifying announcement.

(3) MEETING WITH THE MINISTER OF DEFENCE

The Executive saw the Minister of Defence (Hon. T. L. Macdonald) on 9th November, and briefly outlined the industry's capacity to undertake defence work if called upon to do so. The Executive pointed out that there was a need for minimum reserves of strategic raw materials and components, and urged the Government to take some protective action. The Minister listened with care and courtesy, and promised to go into the matter with his advisers, and to discuss it again with the Executive at a later date.

(4) In addition to the above most important items, several other matters which arose out of the annual conference have been attended to, or have had action initiated.

* * *

A well-known radio trade personality, Mr. W. J. Truscott, Chairman of Directors of Radio (1936) Ltd., was paid a warm tribute by the President of the New Zealand Manufacturers' Federation (Mr. S. Howard Hunter) at a recent meeting of the Council of that body.

Mr. Hunter spoke of the splendid work done by Mr. Truscott over a long period as a member of the Federation Council. In 1937 he was Vice-President of the Auckland Manufacturers' Association, and since that time he has been intimately connected with the affairs of the Federation, having been elected vice-president in 1943, and president in 1946 and 1947. Subsequently, Mr. Truscott had remained a member of the Council by virtue of his office as immediate past president.

In addition to his presidential duties, Mr. Truscott had represented the Federation on a number of other bodies, which had necessitated frequent visits to Wellington, and he had not spared himself in furthering the interests of the Federation.

Mr. Hunter referred to the progress which had been made by the Federation under Mr. Truscott's leadership and said that his wisdom, coupled with a fund of good humour, and a determination to see a matter through to the finish, had assisted in solving many a difficult problem.

* * *

TURNBULL & JONES, LTD.

Annual Managers' Conference held at Wellington, 13th to 17th November, 1950

Round the conference table at the Turnbull and Jones managers' conference.

At the annual managers' conference of Messrs. Turnbull and Jones, Ltd., the whole of the company's activities came up for review. As a result of these deliberations, certain beneficial changes are to be made in the policy of the company, and in its merchandising of certain lines. New projects were also discussed, and final decisions were made, but although these plans are not for immediate publication, the trade should benefit by some of the decisions made. In particular, advertising and selling are to be stepped up in order to do full justice to the many prominent sole agencies held by the company, although the balance sheets over the last few years indicate that there has already been considerable expansion in almost all activities in which the company has been engaged.

The conference occupied a full five days, and in order to get through the heavy agenda in the time available, some night sessions were necessary.

The company has had a long association with the early electrical and radio history of the country, and recent indications, of which this conference is an example, show that the company is quite as lively as ever before, and it is expected that considerable improvements can be looked for with the present progressive outlook.

Mr. E. W. Meyer, who was previously on the head office engineering staff, attended the conference for the first time in his new capacity of Wellington Branch Manager. It is felt that his many friends will wish him every success in his new position.

Another personality at the conference was Mr. Maitland-Jones, who until comparatively recently, was the manager of the company's London office—a position he held with distinction and credit for thirty years. It was largely due to his activities during the blitz of London, and right through the war years, that the company was able to maintain any reasonable flow of merchandise and materials. Mr. Maitland-Jones has returned to New Zealand for a well-earned rest, and his position in London has been taken over by Mr. A. C. Day, A.C.G.I., B.Sc., who was previously the company's chief engineer in New Zealand.

* * *

SEVENTEENTH NATIONAL RADIO SHOW, BIRMINGHAM

From the United Kingdom Radio Industrial Council we have received a souvenir catalogue of the 1950 National Radio Show, which to mark the inauguration of the new TV station at Sutton Coldfield, was held at Castle Bromwich, Birmingham.

Full of informative reading and beautifully illustrated, this catalogue entices the most sanguine of show-goers and to the not so lucky people who could not attend, it gives a most informative review of present-day radio and television receivers.

In the foreword to this catalogue Mr. J. W. Ridgway, O.B.E., Chairman of the Radio Industry Council, says: "As might be expected, in this exhibition the accent is on television. Other aspects of the radio industry are by no means overlooked, however, and, in addition to television, visitors will see displayed the most modern developments in domestic radio receivers, communications equipment, navigation aids, and the use of electronic devices in industry, as well as typical specimens of the valves and component parts which go to make up these many and varied types of apparatus."

Further in the catalogue, Mr. Roy C. Norris, Technical Editor of Electrical and Radio Trading, apparently realizing the front page news which TV now receives, speaks for the radio receiver in an article entitled "Radio Receivers are Better Companions than Ever," and prefaces his talk by saying, "At the exhibition you will find sets that are more versatile, smaller sets and prettier sets, sets that recreate sound with uncanny realism. You will find that radio has more to offer and that, whatever your tastes, you have a wider choice."

With the air in New Zealand at present fluttering with the prospects of TV, *R. & E.* draws special attention to the above comments, for fatal would it be to the radio industry today were to public to take too literally the advent of TV in New Zealand and postpone purchasing that much desired new radio receiver.

Mr. Harold Wilson, President of the Board of Trade (U.K.), in a special message published in the souvenir, sums up the radio TV question when the says: "There is no fear of television supplanting ordinary radio broadcasting. There is and will be a place for both." So as in England will the position be in New Zealand.

Book Reviews

Radio Engineering Handbook (Fourth Edition), by Keith Henney. Publishers, Messrs. McGraw-Hill Book Company Inc.

Radio engineers will find in this volume an old friend in a new guise. "Henney" has long been known and sought after as a practical handbook covering the ever-widening field of radio, and this latest edition more than lives up to the standard of the previous ones. The old format with the small page has been done away with, and this has resulted in a book that is much easier to read and handle—a point that is not unimportant, however excellent the material inside. The fourth edition is printed on a page approximately nine inches by six, and in spite of its 1200 pages, is not unduly heavy, nor is it so thick as to make it difficult to use.

There is little need to describe the manner of presentation, which adheres very closely to that of Mr. Henney's previous volumes. The material, however, has been altered considerably. Much of it is new, as for example the chapters on inductance and magnetic materials, antennas, receiving systems, and radio aids to navigation. The tremendous advances during the war years have seen the development of a great many things which were merely ideas which the 1941 edition was printed, and which thus had no place in a practical manual. These have been included in the new edition, as one might have reason to expect.

One notable omission, or rather, near-omission, is that of modern wire and tape recording. The former is given a very sketchy treatment in the chapter on radio broadcasting, where it appears under the heading of Programme Recording Facilities. Just how sketchy the section is can be gauged from the fact that there is not even a mention of the use of supersonic bias. One might reasonably have expected a volume of this nature to make rather a feature of such an important development as this, especially since so much of the development work was carried out in the U.S.A. Even such information as is given is palpably out of date, as evidenced by the statement that " . . . a speed of 10 ft./sec. has been found necessary for satisfactory recording on the wire of frequencies as high as 2000 c/sec., which would mean correspondingly a speed of 30 ft./sec. to extend the range to 6000 cycles."

The chapter on television, written by Donald G. Fink, could, it was felt, have usefully given more space to the subject of receiver design, and current receiving techniques. For instance, such an important development as the inter-carrier method of separating the vision and sound signals does not appear to have been mentioned. The treatment is excellent as far as it goes, but is limited rather to general principles, such as wide-band amplification, and the generation of video signals, rather than to the description of current techniques. Some of the material on TV transmitters, which are dealt with in more detail, dates from 1939. It is probably still perfectly applicable, but it seems hardly likely that more modern examples of the same techniques would not have been an improvement.

The above criticisms are, however, minor matters. The new "Henney," like its predecessors, is a mine of useful information, and it might almost be said to be worth having for the comprehensive bibliography alone. This, it will be noted, does not confine itself solely to American sources, and British and foreign workers are well represented.

ADVICE FOR TRAIN TRAVELLERS

Check Luggage the Previous Day

Attend to the checking of your luggage the day before you travel, particularly when it is to go to a station in the other island. You're then relieved of luggage-worry and can be sure your belongings will be ready for delivery when you arrive at your destination station. Address each piece of luggage clearly—BLOCK letters on a white label—and remove or obliterate all old addresses and destination labels. Your name and address also should be inside each package.

Avoid Bother With Baggage

Amateur TV

(Continued from page 8.)

is wasted during the retrace of the line time-base, because during this period, too, the spot cannot be used for producing the picture.

Transferring our attention now to the line time-base generator and amplifier circuit, we find that considerably more valves have been used than in the corresponding part of the frame circuit. This is unfortunate, because the two parts of the circuit do exactly the same thing, the only difference being that the line time-base does it at many times the rate of the frame time-base. But as we will see later, doing things at high speed requires more bandwidth, and for that reason an extra amplifying valve has to be used, and also the circuit has had to be altered from a triode amplifier to a pentode amplifier. However, we will go into those aspects when we come to discuss the circuits in detail.

V_5 is an oscillator, working at approximately 15,000 c/sec. This is 300 times the frame frequency of 50 c/sec., so that we must get 300 line deflections for every frame deflection. In other words, the C.R.T. spot executes 300 horizontal sweeps in the time taken for the vertical deflecting voltage to take the spot from the top of the picture to the bottom. The picture must, therefore, be a 300-line one. This frequency, and therefore, number of lines, has not been chosen haphazard, but with a purpose which will be detailed later. At the moment, it will be sufficient to say that 300 lines are enough to give a picture of excellent quality, not so good as the British standard of 405 lines, nor yet the American one of 525 lines, but still enough to give a really good picture that will certainly be worth looking at. V_6 is another EN31, in an almost identical circuit to that of V_3, except for the frequency, and gives the same sort of saw-tooth output. V_7 and V_8 are amplifier and phase inverter respectively, which again provide a push-pull deflecting voltage for the X plates of the C.R.T.

The remaining valves, V_4 and V_{10}, are concerned solely with the production of the blackout voltage for the C.R.T. grid, and their functions will be described later in greater detail.

It so happens that at the cathodes of the saw-tooth generator valves, a positive pulse occurs, and this pulse corresponds exactly in duration with the flyback of the saw-tooth in each case. But to black the spot out, a negative pulse is needed. We therefore insert a pulse amplifier, one for the line blackout pulse, and the other for the frame pulse. Then the two pulses are added together in a cathode-follower adding circuit, and the output of this stage is sent to the grid of the C.R.T., blacking out each flyback as it occurs.

(To be continued.)

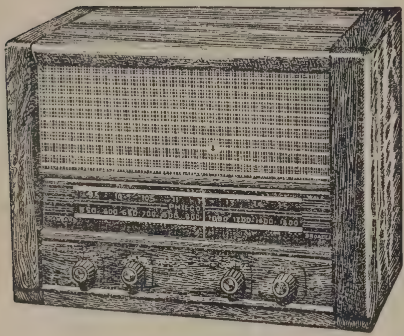
"RADIO AND ELECTRONICS"

Back and current numbers of "Radio and Electronics" may be obtained from—

Te Aro Book Depot, Courtenay Place, Wellington.
S.O.S. Radio, Ltd., 283 Queen Street, Auckland.
S.O.S. Radio, Ltd., 1 Ward Street, Hamilton.
Tricity House, 209 Manchester St., Christchurch.
Ken's Newsagency, 133–135 Stuart St., Dunedin.

NEW PRODUCTS: LATEST RELEASES IN ELECTRICAL AND ELECTRONIC EQUIPMENT

PHILCO MODEL 622



Russell Import Co., Ltd., the wholesale distributors for "Philco," announce the release of the above addition to the "Philco" range.

The set, which is a 6-tube dual-wave set, is designed for straight-out A.C. operation, and features an efficient superheterodyne circuit, specially designed for high sensitivity, high selectivity, and low noise level.

Tube complement is as follows:
1 Loktal 7B7, R.F. amplifier.
1 Loktal 7S7, converter.
1 Loktal 7B7, I.F. amplifier.
1 Loktal 7C6, second detector and first audio.
1 Loktal 7S7, output.
1 Octal 5Y3, rectifier.

The two tuning bands are as follows:
Broadcast band, 535–1620 kc/sec.
Shortwave band, 31m., 25m., 19m.

On the shortwave band, electrical spread band tuning permits ease of tuning.

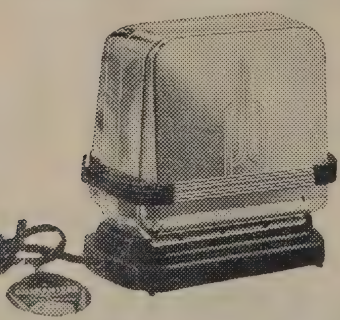
A pleasing feature of the set is the extra large dial, which gives 11½ inches of usable scale space. This, coupled with the two-speed tuning makes for ease and speedy tuning of both broadcast and short-wave stations.

The set is equipped with an elliptical 9 in. x 6 in. speaker accurately matched to the "Philco" circuit. The set is housed in a commanding walnut cabinet of dignified design and distinctive appearance. The choice of veneers is particularly suited to match the expanded metal speaker grille.

The performance of the set is in keeping with what one would expect from PHILCO.

* * *

ULTIMATE ELECTRIC TOASTER



Model No. 330

The modern high - quality toaster pictured opposite is both reliable and efficient. Because it is constructed of finest grade brass and is heavily chromium plated, the toaster withstands heat, and will neither rust nor corrode, thus retaining its original handsome appearance. Fitted with a quick heating element of best nichrome ribbon wire and bonded mica, the toaster will give years of trouble-free service. Tray springs are concealed outside the toaster and away from heat area. Model 330 is mounted on strong moulded black phenolic base and has moulded easy grip tray handles.

Specifications:

Rating: 600 watts, 230 volts.

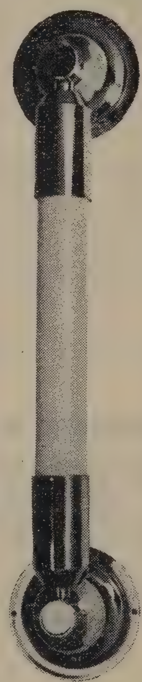
Power cable: Six-foot flexible with durable appliance plug attached.

Retail price: £2 15s.

* * *

PANAMA CANDLE LAMPS

As Opal Tubular Lamps are back on the New Zealand market, Cory-Wright and Salmon have produced a very very neat chromium plated fitting to take the 40-watt or 60-watt B.C. type lamp. It is the Panama B.C. candle



501 and 502 and lamp.

501 and lamp

lamp fitting No. 501 and 502. The 501 includes a B.C. lamp holder and the 502 is plain, so that the latter can be used as a "cap" at the opposite end of the lamp for either vertical or horizontal burning. These are excellent fittings for using alongside or above a mirror.

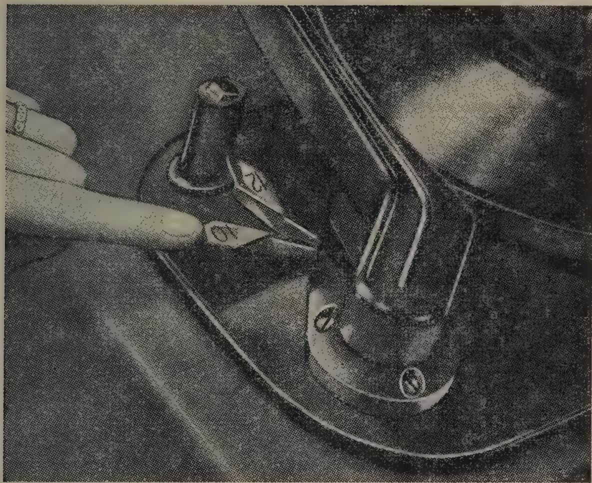
Retail prices: Lamp, 6s. 2d.; 501, 19s.; 502, 13s. 501 and 502 and lamp, 38s. 2d.

* * *

"PLESSEY" RECORD PLAYER, "B" TYPE

Messrs. Swan Electric Co. Ltd. announce supplies of "Plessey" Single Player Type "B" are now available at all their branches.

The exclusive press-button feature of the "B" type Single Record Player is proving an important selling feature on radiograms incorporating this unit. Apart from its novelty and inherent sales appeal, however, it has several important practical advantages;



(*a*) A greater freedom of cabinet design is given to manufacturers, because the installed height of the playing table is unimportant. The user simply slips the record on, and presses the appropriate button. The designer's usual rule, therefore, that the playing table must be conveniently high to allow the user to place the needle on the record track, no longer applies.

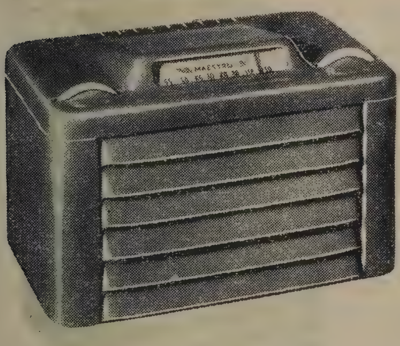
(*b*) Similarly, the visibility of the table is no longer important as the action of playing records has been so simplified.

(*c*) Damage to the records is reduced because the mechanism gently places the needle on the record, switching off automatically at the end of the record.

The mechanism of the unit is extremely simple and robust and is supplied mounted complete on a pressed steel base-plate.

* * *

THE NEW MAESTRO 503



This is a five-valve A.C. broadcast radio, ultra-modern in design, and released in an attractive colour range. The perspex cabinet measures 5¾in. x 9¼in. x 6½in. overall.

A "Rola" 5in. speaker is mounted on a baffle and this and the dial assembly are mounted on the chassis. The complete set is removed from the cabinet by the removal of four readily accessible screws. The tube line-up is 6BE6, 6BA6, 6AV6, 6AQ5, and 6X4, all of which are conveniently placed.

This set has a splendid performance and excellent tone and by virtue of its light weight is easily carried from room to room. Price retail, £17 17s.

Manufactured and distributed by L. A. Chaston Ltd., Box 306, Te Aro, Wellington.

Another "Radio & Electronics" Service

Accurately Known Resistor and Condenser Values

There are numerous purposes for which it is desirable to know the value of a resistor or condenser to a higher degree of accuracy than the normal 10 or 20 per cent. tolerance to which such components are made. Since most amateurs do not have the instruments with which to measure resistors and condensers with any accuracy, it has been decided to place our own facilities at the disposal of readers in consideration of a small fee. The manner in which the *Radio and Electronics* Measurement Service will operate is as follows:—

(1) Readers may send or bring to our office resistors or condensers whose value they wish to have measured. Each resistor or condenser must be accompanied by a fee of 9d. (ninepence), and in the case of parts received by post, these will be returned to the owner post free.

(2) The values assigned will be accurate to within plus or minus two per cent.

(3) Resistors between the values of 0.1 ohm and 10 megohms, and condensers between the values of 10 $\mu\mu$f. and 100 μf. will be capable of being measured on the equipment at present in our laboratory.

(4) *Matching*

For a special matching fee of 2/6, batches of resistors, or condensers, of the same nominal value will be axamined, and the owner advised whether any two are matched to within specified limits. Batches must not exceed 12 components, and a reduced measuring fee of 6d. per resistor or condenser will be charged in respect of each member of the batch.

Example: Six 10k. resistors are sent with a request that they be examined for a pair matched to within 0.5 per cent. The charge will be 6d. for each resistor, plus 2s. 6d. matching fee, totalling 5/6. They are received back by the owner, each with its value, correct to plus or minus two per cent. marked on it, together with an indication of which pair is matched to the tolerance requested. Should no pair come within the desired tolerance, an indication will be given of which pair is closest, and to what tolerance.

Note.—The bridge on which the measurements will be made is capable of measuring a given value to an accuracy of 2 per cent., and of matching pairs to a tolerance of 0.5 per cent.

Sir George Nelson

A DISTINGUISHED INDUSTRIALIST AND ENGINEER VISITS NEW ZEALAND

This journal was recently privileged to have a personal interview with one of Britain's most distinguished electrical engineers, Sir George Nelson, while he was in Wellington during the course of a world tour. Sir George is the Chairman and Managing Director of the English Electric Co., Ltd., which is one of the largest groups of engineering companies in the world today. The parent company is perhaps best known for its heavy electrical engineering work, and in particular for its activity in electric traction and hydro-electric machinery, in both of which fields it has contributed in no small way to developments in this country.

Its interests have, however, been greatly extended in recent years, in particular by the purchase of the world group of Marconi companies and Siemens Ltd., to mention only two. For instance, another old and famous member of the present group is the Napier Company, Sir George told us. This firm was established in 1808, and the first of a long series of precision engineering achievements was the construction of machinery for weighing sovereigns at the Royal Mint.

It is hardly surprising, then, that with the very wide range of interests and capabilities that the English Electric group represents, that the group is able to turn its hand to making almost anything. Sir George described how it comes about that Britain's first jet-propelled bomber was designed and built by the English Electric Co. The company embarked on aircraft manufacture during the late war in order to increase the country's output of fighting aircraft, and built very large numbers of the De Havilland Mosquito. The first jet aircraft produced by the company, Sir George said, was the Vampire, another De Havilland design. In fact, the Vampires which will be delivered to the R.N.Z.A.F. are made by the English Electric Co. So successfully did the company produce the Vampire, that it was asked to design a jet bomber, and the Canberra, now in the forefront of the R.A.F.'s potential bombing strength, was the result.

Television was also a subject in which Sir George's group of companies is vitally interested, since the original development and construction of the Alexandra Palace transmitting station was done by the Marconi Company, and Sir George himself is a firm believer in the immense potential of television as an educative medium. He expressed himself as being particularly interested in the present status of TV in this country, and in the fact that the manufacturers here had decided to do all in their power to bring television closer.

One matter which Sir George was concerned to publicize during his tour was that in the English Electric group, Britain had an organization for research, development, and production that had few rivals anywhere in the world. Too often, he considers, it is assumed that the great American combines are the only ones with the remarkable research facilities for which they are justly famous. The English Electric group was served by the great Nelson Laboratories, in which £3,000,000 a year is being spent on research of all kinds, including fundamental scientific research. The laborataories were busy, among other things, on the development of the medical aspects of application of atomic energy, and were also carrying out research programmes in connection with the development of radar and other electronic service equipment.

THE NEW ZEALAND ELECTRONICS INSTITUTE (Inc.) NEWSLETTER

HEADQUARTERS NEWS

Subscriptions: At a recent Council meeting reference was made to members who had not yet paid their current year's subscription. All members have received notification of the amounts due and Council agreed that unless prompt payment was made it would be necessary to inform these unfinancial members of the constitutional position. Under these circumstances it was felt that publication of the particular Rules concerned should be made.

Section 8 (e) of the Institute Constitution states:—

"In the case of any member whose subscription remains unpaid at the end of two months from the beginning of any financial year the Secretary shall inform him that his membership has lapsed."

The practical application of the above-mentioned rule has not been carried out but Section 11 states:

"Any member wishing to resign his membership shall forward notice in writing, of his desire to resign together with any property of the Institute to the Secretary of the Institute on or before the seventh day prior to the Annual General Meeting in any year, and provided that his subscription is paid, shall be released from membership."

The Council naturally are most reluctant to act in accordance with the Constitution as it is desired to retain members' interest rather than lose their association with the electronics organization, but members will appreciate that with the advent of the dispatch of *Radio and Electronics* to all members, Council has entered upon a heavy commitment and it is therefore felt that, if necessary, the roll should be brought up to date. An appeal is therefore issued to those members who are unfinancial to forward their subscriptions promptly and in order to assist early payment we detail below the names and addresses of the branch representatives to whom payment may be made:

Branch Representatives:

Auckland, Acting Secretary, Mr. A. O. Valintine, 33 High Street, Auckland.

Christchurch, Treasurer, Mr. J. Allen Lee, 41 Valley Road, Cashmere Hills.

Dunedin, Secretary/Treasurer, Mr. W. McInnes, Box 243, Dunedin.

Wellington, Acting-Treasurer, Mr. W. D. Foster, 77 Mantell Street, Wellington.

General Secretary, P.O. Box 1368, Wellington.

Prize Award:

Advice has been received from the Electrical Wiremen's Registration Board of New Zealand that the candidate who gained the highest marks in the Radio Servicemen's Written Examination was Mr. Eric Russell Petherick, of 12 Reuben Avenue, Brooklyn, who secured 49 out of a possible 50 marks. The congratulations of Council are extended to this officer on his meritorious performance and the usual Institute prize award of technical books to the value of £2 2s. is being arranged.

Admissions and Regrading of Members:

At the council meeting held during December the following applications were approved:

Admission as Associate—G. Applegarth, Flat 10, R.N.Z.A.F. Station, Taieri; L. D. Lewis, Flat 8, R.N.Z.A.F. Station, Taieri.

Regrading from Student to Associate.—B. C. A. Pryce, Civil Aviation, P.O. Box 38, Wanganui.

A cordial welcome is extended to the two new members, and it is hoped that their association with the Institute will be one of mutual pleasure and benefit.

Institute Insignia:

Members will be pleased to learn that final arrangements are in train to utilize the Institute crest on all stationery and documents issued. It is hoped to also use the crest very shortly at the head of this newsletter.

Programme:

Considerable discussion ensued in connection with district programmes and the following suggestions were advanced and are published hereunder for consideration of district members:

(i) That a syllabus of lectures be drawn up early in the Institute year and promulgated promptly. By adopting this method branches can advise their members in advance of practically all functions and obviate any misunderstandings about specific dates.

(ii) That the Institute endeavour to interest itself in television by delivery throughout the Dominion of a series of lectures on this important subject. To further this project a sub-committee was set up from the Council to compile suitable titles for lectures and the distribution of these titles to branches in order that speakers can be arranged.

(iii) A further suggestion was advanced that any outstanding lectures delivered in the Dominion be recorded and after editing, the tape of the recording be circulated to all branches.

Supporting Bodies

It was decided to seek the continued support of industry, and the matter was left in the hands of a sub-committee to further. As members are aware, various organizations throughout the Dominion very kindly assisted the Institute financially in 1949, and although the finances of the Institute are now in a better position, it was felt that supporting bodies could still help the further development of the Institute.

Articles for Publication:

A discussion took place on possible extension of the Institute section in *Radio and Electronics* and it was agreed that members be invited to submit suitable articles for publication and an arrangement was made with *Radio and Electronics* whereby payment should be made for such articles if considered suitable for reproduction. Members are therefore invited to take full advantage of this generous offer by the proprietors of *Radio and Electronics* and submit original and informative articles which, if published, would disseminate additional information regarding the science of electronics generally. This would then assist in furthering the objectives of this, your Institute.

Branch News:

Due to lack of space it has not been possible to publish branch news, but it was felt that members should be informed of a recent function held in Christchurch whereby Mr. T. C. Agar, a member of the N.Z.B.S. Recording Technical Staff, addressed members on a very important subject, viz., "Modern Recording Technique."

Mr. Agar opened with a survey of typical circuits used in the recorders, and outlined the theory behind the use of "radius compensation" and "frequency equalization" as applied to disk recording. The E.M.I. tape recorders were briefly described and an explanation given of the necessity for, and action of, "supersonic bias." Reference was made to the very high quality of which these machines are capable, and an explanation given of the important features which helped to achieve this result.

A Reliable Miniature Electric Motor

PART II

In the first part of this article, the construction of the motor frame was detailed, and drawings were given which showed the construction of the motor very clearly. Most of the things that have not yet been described are almost self-evident from the drawings, and so will require little further comment.

THE BRUSH GEAR

This is built on a third drum from the counter mechanism. Two holes are made in it, and through these come the supporting rods for the shim brass brushes. On the outside of the drum, which cannot be seen in the drawing, a circle of fibre is held by means of small nuts and bolts to the drum. These bolts are insulated from the drum by enlarging the holes through which they go, and by placing on the inside a further fibre washer, whose shape can be seen in the drawing. The bolts are then able to be used for soldering the connecting wires on to. The shim-brass brushes, also visible in the drawing, are soldered on to short lengths of 16-gauge copper wire. These go through the large clearing holes in the drum, and are in turn soldered to small brass strips, whose other ends are held under the heads of the mounting bolts. These strips can be seen in the photograph on page 9 of the November 1950 issue, and intending builders should have no difficulty in following the construction if they take this photograph in conjunction with the drawing. The clamping ring is made of shim brass, and two small stiffeners of brass sheet are soldered to the bent-up ends so that the tension of the fixing bolt will not tear the thin shim brass. This method of mounting the brushes allows the whole bearing plate, with the brushes, to be rotated to the position which gives the best running of the motor.

THE COMMUTATOR

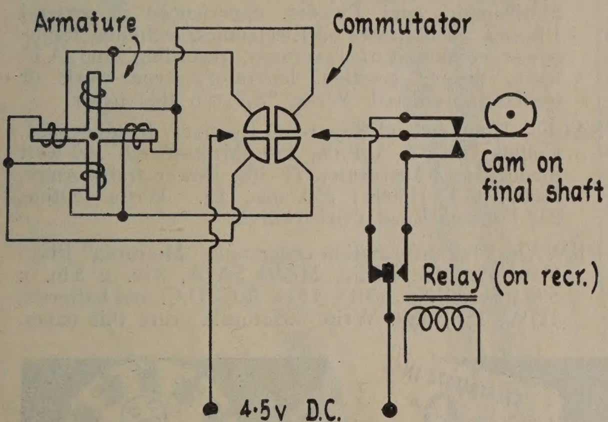
This is made from a circle of fibre to which the shim brass segments are glued. A small lug is provided at one outside edge of each segment, and taken through a shallow saw cut in the fibre, round to the back of the fibre disk. These lugs are then used as the points to which the wires from the winding are attached.

THE ARMATURE

The easiest way to make the armature is to cut it from a solid piece of soft iron using a hack-saw, and a file to clean up the sawn surfaces. After it is made, a hole

for the shaft is made with a 1/32 in. drill right through the centre. This is not an easy job, and it may be simpler to drill the hole through the block first, when the only thing to worry about is getting the hole accurately at right-angles to the end faces. This done, the block can be filed to the exact size, and the cut-outs laid out and removed with the saw.

The drawing shows how the wire is wound on the armature, and the circuit diagram on this page shows how the connections are made to the commutator. The latter is mounted to the shaft by gluing it to one of the small gear wheels from the counter mechanism, and



Wiring diagram of the complete actuator. Note that the four coils are wound in the same direction on all legs of the armature and that each commutator segment is connected to one junction point between coils.

using the hub and set-screw to fix the whole thing to the shaft. Note that the armature must not be made too long, as the commutator as well as the armature has to go into the magnet assembly.

THE QUARTER-TURN CAM

In making up the complete mechanism, one can please oneself about the exact degree of gearing down to be used. As mentioned before, our own used approximately 50 to one, and it is not considered that less than this would be satisfactory. The cam itself can be made from a piece of copper or brass about 24 gauge in thickness, and soldered to a hub from one of the counter gear wheels. The diagram shows the general shape of the cam, which should have the raised portions exactly opposite each other, and occupying a quarter of the circumference each. The switch leaves can be got from telephone-type push switches, and it is important to note that they must be bent in such a way that for a brief period while the centre leaf is changing position, BOTH THE OUTSIDE CONTACTS MUST MAKE. Owing to the free-running nature of the motor, it will be found that the final shaft overruns for about an eighth of a turn of the cam before the motor stops, but this does not matter, because the overrun is the same each time it stops, and the positions are still a quarter of a turn apart.

The detail of the gearing mechanism is intended only to be illustrative, showing one way in which the problem can be solved. Some builders will no doubt prefer to use a worm-type reduction drive, and the wiping contact type of motor-stopping mechanism, but as long as the system used is reliably made, it is of no consequence which is employed.

The "R. and E." Abstract Service

ANTENNAE AND TRANSMISSION LINES

An antenna developed for cars and buses is of the "curtain rod" type, so called because of its physical appearance, and its properties are worthy of study on account of convenience.
—*Electronics* (U.S.A.), October, 1950, p. 78.

There is wide use of what is known as the Yagi antenna for television reception, but little information is available as to the width of the band over which the pattern and match will remain acceptable. In this type the parasitic element acts as director, and the frequency range available is discussed.
—*QST* (U.S.A.), October, 1950, p. 18.

AUDIO EQUIPMENT AND DESIGN:

Practical methods are given of servicing P.A. systems where several speakers are connected in series-parallel, and of estimating impedances for matching the units. Various troubles are discussed with the remedies.
—*Service* (U.S.A.), August, 1950, p. 38.

Recording and fine-groove technique, a study of equipment, recording technique, record constants, number of grooves per inch, and recorder design features.
—*Audio Engineering* (U.S.A.), September, 1950, p. 12.

Automatic gain controls for audio systems—a discussion of the development and application of programme-controlled circuits in broadcasting, with a description of a general-purpose device in regular use. With this equipment line levels may be held more constant, the average level increased many fold, and the listening public subjected to less sudden changes of sound volume.
—*Audio Engineering* (U.S.A.), September, 1950, p. 16.

ELECTRONIC DEVICES:

Rejuvenate those electrolytics. An old condenser may easily burn out a power supply. Where there is heavy leakage in an electrolytic it may be overcome by aging the condenser through the application of a voltage prior to its use, and a suitable device for this purpose is described.
—*Radio and Television News* (U.S.A.), Oct., 1950, p. 84.

MATERIALS AND SUBSIDIARY TECHNIQUES:

A treatise on gettering—comparison of getter efficiency for various types of metals and gases—tantalum, columbium, zirconium, thorium, titanium, aluminium, magnesium, barium, and phosphorus, and their respective uses.
—*Electronics* (U.S.A.), October, 1950, p. 87.

Standards of electron tubes, Part III—non-linear characteristics—power output—electrode dissipation—methods of testing cathode ray tubes—gas tubes—cold cathode and voltage-regulator gas tubes.
—*Proceedings of the I.R.E.* (U.S.A.), Sept., 1950, p. 1079.

MATHEMATICS:

Dynamical analogies—in designing and studying electro-mechanical and electro-acoustical equipment, the ability to reduce the entire system to a common basis facilitates mathematical analysis. The common basis lies in the use of dynamical analogies, for instance, in electronics, inductance has its counterpart in acoustics in inertance, and in dynamics, mass. These analogies are an interesting improvement on the old water analogy systems.
—*Audio Engineering* (U.S.A.), September, 1950, p. 20.

Calculating U.H.F. field intensities. Curves based upon accepted propagation concepts facilitate theoretical prediction of television field intensities betwen 470 and 890 mc/sec. until more experience is obtained. Data on nulls and maxima resulting from path differences are included to show their location in miles from the transmitter.
—*Electronics* (U.S.A.), October, 1950, p. 110.

Cathode follower response. The chart gives permissible cathode-follower pulse drive at video frequencies in terms of low-frequency sinusoidal input. Video frequency overloading and distortion in conventionally loaded circuits originate in output time constant.
—*Electronics* (U.S.A.),, October, 1950, p. 114.

The M.K.S. of Giorgi system of units. The underlying principles are explained, showing that it is not designed to replace the C.G.S. system but that it is an extension of the present set of practical units into a complete absolute system, which embodies mechanical, electrical, and magnetic units, and which is intended to replace the mixed system and C.G.S. units customarily used by electrical engineers.
—*Proceedings of the I.E.E.* (Eng.), Part. I, Sept., 1950, p. 245.

MEASUREMENTS AND TEST GEAR:

Limitations and Uses of Sweep Generators for TV servicing. With over four million TV sets in the U.S.A. servicing has become a major enterprise. It is imperative that every serviceman be equipped with a TV-FM sweep generator. A critical analysis of the generator's capabilities is given.
—*Service* (U.S.A.), August, 1950, p. 25.

Audio Frequency Meter

(Continued from Page 29.)

meter would be 0 to 8000 c/sec. And, other things being equal, a 0.0001 μf. condenser would give a range of 0 to 80 kc/sec.

Theoretically, it can be seen from Equation (1) that the meter current does not depend on the value of the load resistance R, but in practice, the value of this resistor does have an important effect, because if it is made too large, it limits the highest frequency that can be measured, since it makes the condenser take too long to charge completely. It is a matter of common knowledge that if a condenser C charges through a resistance R, the time taken for it to charge to 67 per cent. of the applied voltage is measured by the product RC, and is given in seconds if the R is in megohms and C in microfarads. But we want the condenser to charge completely before the square-wave half-cycle is completed, so that for any value of the condenser and the resistor there is an upper limit to the frequency that can be measured before the current ceases to be a linear indication of the frequency. In practice, it is found that the time constant of the load resistor and the condenser C must be approximately equal to one-fifth of the time of one half-cycle of the square-wave input. If this fact is taken into consideration at the same time as the equation which predicts the meter current, it is found that there is a maximum meter current, irrespective of frequency, up to which the indications are linear with respect to frequency. Now as long as this maximum current is well above the full-scale current of the meter used, then we shall have no trouble from this source of inaccuracy, and the overall accuracy of the meter will depend solely on the accuracy of the indicating meter and the stability with which the square-wave voltage is generated. For those who may wish to use other meters than a 0–1 ma. movement, the formula giving the maximum allowable meter current is:—

$$i < \frac{V}{9.2R}$$

where i is in amps, V in volts, and R in ohms.

(To be continued.)

CLASSIFIED ADVERTISEMENTS

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